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AHANGAREN FOREST DAMAGE PROJECT: FINAL REPORT, MARCH 2011

Karl H. Thunes and Gulusa Vildanova (Eds.)

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Sammendrag: The collapse of the Soviet Union in the Central Asian countries has led to enormous challenges for them ensuring a sustainable environment. Weak economies, weak institutions and lack of environmental sciences expertise were important reasons for the Norwegian support to the environmental sector in this region. The State Forest Service of the Kyrgyz Republic and the Norwegian Forestry Group initiated the TEMP project, later renamed TEMP-CA, in the Kyrgyz Republic in 2004. TEMP-activities in the Republic of Tajikistan were included in 2007 and in the Republic of Uzbekistan from 2008. In 2008, as a spin-off of TEMP-CA, the Ahangaran Forest Damage Project was initiated realizing that the Juniper forests surrounding the town of Angren were under environmental constrain, possibly due to massive industrial activities.

The forestry sectors in Uzbekistan and neighbouring countries in Central Asia, surrounding the Fergana Valley, are closely linked to the environmental and emergency planning sectors. Overgrazing and overharvesting have contributed to a dramatic decline in forest cover. The Ahangaran Forest Damage Project, together with the TEMP-CA projects contributes to a better understanding of environmental problems and sustainable forestry in Central Asia.

All Central Asian projects have promoted institutional co-operation between Norway and the Central Asian countries as well as between different institutions both within and between the countries of Central Asia. Increased expertise for scientists, fieldworkers, laboratory staff and staff in different forest departments as well as institutional development in general are important outputs from the projects which are invaluable but can never be denoted in a project report.

The Yangonkli Sai (Yan) site in Tashkent region, the Republic of Uzbekistan, was established as a separate site from the ten sites in the TEMP-CA project (see e.g. Økland et al 2011), even though the layout and data collection procedures were identical to the procedures in TEMP-CA. In addition, during very short field surveys, an overview of fungal pathogens and insect pests were carried out.

Ten plots of 30x30 m were placed subjectively in the area in order to represent the variation in the presumed most important environmental gradients. A 10x10 m plot was placed in the centre of the 30x30 m plots. Within each 10x10 m plot (macro plot) five plots of $1m^2$ were randomly placed.

All trees within the ten 30x30 m plots were marked on a sketch map and a number of tree growth and tree vitality measurements were recorded. The trees at the Umalak site consisted mainly of *Juniperus seravschanica* (98,7%). The two smallest size classes (DBH < 25 cm) represented 50.7% of the trees, indicating adequate regeneration. The size distribution was also characterized by a high proportion of trees in the intermediate size class (DBH 25-35 cm). Defoliation was 38.0%, which is a notable level according to the ICP Forests classification.

Two abundance measures were recorded for all species in each of the fifty $1m^2$ plots: frequency in subplots (presence/absence of all species in sixteen subplots in the $1m^2$ plots) and percentage cover. A total of 79 species of vascular plants were recorded in the 50 $1m^2$ plots, along with 8 bryophytes. 63 of the vascular plants were herbs. The total number of vascular plant species in the 50 $1m^2$ plots + ten $30x30m^2$ plots was 98. Of the recorded vascular plant, 12 are endemic to Central Asia: *Arum korolkovii, Carex turkestanica, Cousinia olgae, Eremurus regelii, Euphorbia jaxartica, Galium pamiroalaicum, Gymnospermium alberti, Iris sogdiana, Prunus sogdiana, Rosa kokanica, Thalictrum sultanabadense,* and *Veronica bucharica.*

Detrended Correspondence Analysis (DCA ordination) of the subplot frequency data for the fifty $1m^2$ plots was performed in order to reveal the most important vegetation gradients. The ordination axes, i.e. expressing the vegetation gradients, were interpreted by means of Kendall's non-parametric correlation coefficient. Differences in topography, soil moisture, soil depths, depths of organic layer and litter layer, grass height, influence of grazing and some nutrients are important environmental factors influencing the species composition in this monitoring area. Probably most of this variation is related to the difference between northern and southern exposed sites, as plots in the southern sites were more strongly influenced by grazing and soil erosion which may also explain also the lower depths of the organic layer and litter layer etc.

The environmental conditions in the Yangonkli-Sai area are diverse and this also influence the soil types: (i) slopes facing north and south, (ii) macro-plots grazed (3 – 7) and ungrazed (1 – 2 and 8 – 10), (iii) north slope with loess and south faced slope with weathered gneiss and rhomb porphyry, (iv) loess soils with a calcareous B and C horizons (sometimes also the A horizon) while the weathered soils were degraded and sometimes with heavy clayey with rocky outcrops, and (v) big and well developed *Juniperus* trees on north faced slope, sparse and small on south faced slope. The soils on the north slope (macroplots 1 – 2 and 4 - 10) were Luvisols. The soil had a well developed B horizon and the C horizon was sometimes not possible to reach. These soils were calcareous and some had secondary chalk noodles. Soil texture varied from a silty loam to a loamy clay.

All the non-fenced parts (macroplots 3 - 7) showed clear signs of overgrazing. Erosion features were common. The soils on the south slope were totally different (macroplot 3). Generally the slope is steep and consists of weathered gneiss/rhombyrporfyr rocky outcrops. The weathered material is varying in texture from sandy silt to a loam to very heavy clay. The soil was not calcareous. The south slope is severely overgrazed and the large parts of the vegetation are dominated by *Eremurus*. Due to overgrazing the soil profile is a B or BC profile. Soiltypes found are Regosol and Leptosol.

A pH around 7.5 prevail at all the sampling plots and soil horizons. The pH does not decrease from the A to the C horizon, though the organic content decreases along with total Carbon content. Studying all samples (across horizons) we find that strong correlations between soil chemical characteristics were only found between % C_{tot} and loss on ignition and total N content. The soil content of adsorbed phosphate (Ads. PO_4^{3-}) is among the lowest among the TEMP-CA sites. In addition to SiO_2 (not measured) the main oxide composition of the mineral soils is made up by aluminium (Al) and iron (Fe), followed by calcium (Ca) and potassium (K). Base cations (Ca+Mg+Na+K) in the A and B horizons account for about 40% - 50% of the oxide composition. The C horizon is richer in base cations, likely due to that the weathering has not been as active as in the A and B horizons. The content of Fe and Al are strongly correlated. Both Al and Fe are correlated to manganese (Mn). The Al content is also as commonly found to co-vary with K, in addition to sodium (Na) as there is a strong correlation between Na and K. The Al and Fe content are also strongly correlated to a number of trace elements such as copper (Cu), nickel (Ni), cobalt (Co), scandium (Sc), caesium (Cs) and as usual with titanium (Ti).

Shoot dieback could be observed in all the plots; on some trees the foliage were reduced by 80% and attack by *Gymnosporangium* sems to be of great importance. Since leaves of the alternate hosts *Cotoneaster pseudomultiflora* and *Crataegus turkestanica* were infected the juniper tress most probably are attacked by *G. confusum* and *G. fusisporium.* Frequent cutting of branches for firewood in combination with climatic stress may have increased the fungal attacks in the area and thus decreased the vitality of the juniper trees.

Signs from insect damage were seen on several trees, most likely from longhorn beetles and bark beetles. Due to short sampling time-span, few adult beetles were collected and only one species was identified.

Ansvarlig signatur: Jeg innestår for at denne rapporten er i samsvar med oppdragsavtalen og Skog og landskaps kvalitetssystem for oppdragsrapporter.

Adm.dir./Avdelingsdirektør

Oppdragsrapport fra Skog og landskap 06/2012

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Karl H. Thunes and Gulusa Vildanova (Eds.)

Cover Photo: Yan, Photo: Halvor Solheim

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ABSTRACT

The collapse of the Soviet Union in the Central Asian countries has led to enormous challenges for them ensuring a sustainable environment. Weak economies, weak institutions and lack of environmental sciences expertise were important reasons for the Norwegian support to the environmental sector in this region. The State Forest Service of the Kyrgyz Republic and the Norwegian Forestry Group initiated the TEMP project, later renamed TEMP-CA, in the Kyrgyz Republic in 2004. TEMP-activities in the Republic of Tajikistan were included in 2007 and in the Republic of Uzbekistan from 2008. In 2008, as a spin-off of TEMP-CA, the Ahangaran Forest Damage Project was initiated realizing that the Juniper forests surrounding the town of Angren were under environmental constrain, possibly due to massive industrial activities.

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All trees within the ten 30x30 m plots were marked on a sketch map and a number of tree growth and tree vitality measurements were recorded. The trees at the Umalak site consisted mainly of *Juniperus seravschanica* (98,7%). The two smallest size classes (DBH < 25 cm) represented 50.7% of the trees, indicating adequate regeneration. The size distribution was also characterized by a high proportion of trees in the intermediate size class (DBH 25-35 cm). Defoliation was 38.0%, which is a notable level according to the ICP Forests classification. Discoloration was almost insignificant. Juniper trees in the area are attacked by *Gymnosporangium*, since leaves of two secondary hosts (*Cotoneaster pseudomultiflora* and *Crataegus turkestanica*) were infected by the fungus. Frequent cutting of branches for firewood in combination with climatic stress may have increased the fungal attacks in the area and thus the vitality of the juniper trees.

Two abundance measures were recorded for all species in each of the fifty 1m^2 plots: frequency in subplots (presence/absence of all species in sixteen subplots in the 1m^2 plots) and percentage cover. A total of 78 species of vascular plants were recorded in the 50 1m^2 plots, along with 8 bryophytes. 63 of the vascular plants were herbs. The total number of vascular plant species in the in the 50 1m^2 plots + ten 30x30m^2 plots was 98. Of the recorded

vascular plant, 13 are endemic to Central Asia: *Arum korolkovii, Carex turkestanica, Cousinia olgae, Eremurus regelii, Euphorbia jaxartica, Pedicularis krylovii, Galium pamiroalaicum, Gymnospermium alberti, Iris sogdiana, Prunus sogdiana, Rosa kokanica, Thalictrum sultanabadense,* and *Veronica bucharica.*

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Shoot dieback could be observed in all the plots; on some trees the foliage were reduced by 80%. *Gymnosporangium* species were common throughout the area. Secondary hosts of the fungus were also found, giving an indication that most of the damage in this area is due to infestations by *Gymnosporangium* .

Signs from insect damage were seen on several trees, most likely from longhorn beetles and bark beetles. Due to short sampling time-span, no adult beetles were collected to be able to identify them.

PREFACE

The Ahangaran Forest Damage Project was initiated and planned by Odd Eilertsen, who was also the project leader up to his sudden death on 19 February 2010. All involved project partners and scientists in Uzbekistan, Kyrgyzstan and Norway had been working with data-analyses and reporting according to his ideas and decisions up to his death. This report has thus been completed as far as possible accordingly.

Many scientists and colleagues in Norway, Uzbekistan and Kyrgyzstan as well as myself are very grateful to Odd for giving us the possibility to co-operate in this project.

On behalf of all authors and partners I want to give special thanks to the persons mentioned below who have contributed with fieldwork, laboratory work, translations, logistics, administrative work etc.:

Aitkul M. Burhanov, Nicholas Clarke, Zukhriddin Fazylov, Muratbai Sh. Ganiev, Abdushukur A. Khanazarov, Zikrullaeva Khusniya, Antonina I. Knyaz'kova, Ramazan K. Kuziev, Bakyt A. Mamytova, Oleg R. Mujdabaev, Saltanat R. Narynbaeva, Svetlana G. Nesterova, Lyutsian Nikolya and Hamro S. Sabirov.

My very special thanks to Tonje Økland, who supported me and helped me, especially in the last phase of the work with completing this report. I also want to give special thanks to Dan Aamlid (head of the Department for Biology and Environment at NFLI), Halvor Solheim (leader of the Forest Health Section at NFLI) and Øystein Aasaaren (Managing Director of Norwegian Forestry Group), all of whom have, in different ways, given me support in the difficult situation that occurred when Odd died. Odd Eilertsen was the initiator and project leader of NFLI's project portfolio in Central Asia but he was also my friend and colleague.

Bergen, March 30. 2011

Karl H. Thunes

Project leader

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CONTENT

1. INTRODUCTION

Gulusa Vildanova, Gayrat A. Mukhammedov, Tokhir N. Nurulloev, Karl H. Thunes, Tonje Økland & Odd Eilertsen

Various terrestrial monitoring programs in Europe, North America, East and Southeast Asia have shown that combined effects of anthropogenic and natural stresses affect soil, water, vegetation, and forests. Air, soil and water pollution as well as changes in climate are all regarded as important stress factors. The impact of pollutants and changes in climate vary geographically and with site and stand conditions. Different anthropogenic factors and their effects on terrestrial ecosystems are thus complex and difficult to isolate and quantify. A large number of stress factors that influence the ecosystem condition must therefore be taken into consideration and measured in the same plots; i.e. integrated monitoring should be carried out.

The International Co-operative Programme on Assessment and Monitoring of Air Pollution on Forests (ICP Forests) was established under the Geneva Convention - UN/ECE Convention on Long-range Trans-boundary Air Pollution (CLRTAP) in 1985. The Kyrgyz Republic, together with Kazakhstan, are the only countries in Central Asia to sign the Geneva Convention.

After the collapse of the Soviet Union the Central Asian countries have had enormous challenges in securing a sustainable environment. Weak economies and lack of human resources are two of the key factors. After the independence of the former Soviet republics in 1991 many of the Russian and other foreign scientists left Central Asia. The State Forest Service of the Kyrgyz Republic and the Norwegian Forestry Group initiated the Forest and Environmental Sector Programme in 2004. The program included the following two activities:

Activity 1 Terrestrial Environmental Monitoring Programme (TEMP). Implementation of a methodology for monitoring and studying terrestrial ecosystems in the Kyrgyz Republic.

Activity 2 Institutional Strengthening of the forestry sector including a stronger involvement of the private sector in the management of the natural resources.

After the appraisal phase (2003-2004) and Phase I (2005-2006) of the project, forest and environmental activities in the Republic of Tajikistan and the Republic of Uzbekistan were included as well in Phase II, the project was accordingly renamed TEMP-CA and the present project, Ahangaren Forest Damage Project, adopted the practical and theoretical setup with some adjustments, to meet its mandate.

The Central Asian states face tremendous challenges to manage the process of political, economic, and social reforms towards competitive and open market economies. They still suffer from the legacy of the Soviet period, and collaboration between scientists and environmental managers from the different countries is more or less absent. The TEMP-CA project together with the Ahangaren Forest Damage Project aim at bringing scientists and environmental managers from the Kyrgyz Republic, the Republic of Tajikistan, and the Republic of Uzbekistan together in a joint trans-boundary project.

The forest area of the Republic of Uzbekistan is not large: forests cover less than 3 % of the total area. The forestry sector in the Republic of Uzbekistan and its neighbouring countries in Central Asia, especially in the Fergana Valley, are closely linked to the environmental and emergency planning sectors. Excessive grazing and harvesting have contributed to a dramatic decline in forest cover. The history of forestry in the region is similar to that observed in Western Europe: The over-exploitation of the timber resources in the first half of the 20th century resulted in a dramatic decline in forest cover, and led to the establishment of institutions with a mandate to improve forest management and restore depleted mountain forests.

In contrast to Western Europe, the period of timber exploitation was followed by a period of severe overgrazing, which further degraded the forest cover and interrupted natural regeneration. Today, large areas are affected by soil erosion and land degradation. The situation is more or less similar for the neighbouring countries around the Fergana Valley. Besides this, the main land degradation processes include salinization, swamping, chemical pollution, and destructive changes in vegetation cover.

Forest resources play an important role in water regulation, protection from soil erosion, general conservation of biological diversity, and stabilization of the ecological balance. Strong dependence on the use of wood as fuel is challenging, and alternative energy sources need to be explored to prevent further deforestation. Pastures located on slopes with steepness of more than 20 degrees are severely degraded by wind and water erosion. The prevalence of small cattle ranches has led to the transition from pasturing of cattle at a distance from settlements to primitive shepherding, which has expanded the impact area and the forest degradation.

The institutional co-operation between Norway and the Republic of Uzbekistan, the Kyrgyz Republic and the Republic of Tajikistan provides the opportunity for education and training of numerous environmental field workers and scientists, laboratory engineers, forest and environmental experts and managers from the Central Asian region. The Ahangaren Forest Damage Project and TEMP-CA projects contribute to a better understanding of environmental problems, as a first step to promote a sustainable use of the forests in Central Asia. Thus, increased expertise in environmental monitoring methods and in environmental management as well as institutional development in general is the most important output from the project.

In this report we present the main results from the one site that was not a direct part of the TEMP-CA project, Yangonkli-Sai in the Tashkent region in the Republic of Uzbekistan. This site was established and analysed in 2009. Measurements of a lot of variables for forest tree condition, forest growth, soil chemistry, and soil classification, ground vegetation, environmental factors, damage caused by insects and fungi as well as signs from air pollution were taken.

2. DESCRIPTION OF YANGONKLI-SAI (YAN) REFERENCE AREA

Gulusa Vildanova, Nurlan I. Kasymbaev, Gayrat A. Mukhammedov, Tokhir N. Nurulloev, Abdugappar Sharohmatov, and Abdujappar Sharohmatov

2.1. Geographical position of the reference area

The Yangonkli-San (Yan) reference site is located on the northern macro-slope of the Kurama mountain range in the Tien-Shan mountain system (Figs 2.1., 2.2., Tab. 2.1.). The total area of the forestry enterprise, according to the data of the last forest inventory, is 183,466 hectares and consists of five separate sites, one of which is located on southern slopes of Chatkal range (Kendjagal) and the others are located on northern slopes of Kurama range (Almalyk, Gushsai, Akcha and Parkent forest units).

The extension of territory of the forestry enterprise from the north to the south is 38 km and from west to east - 40 km.

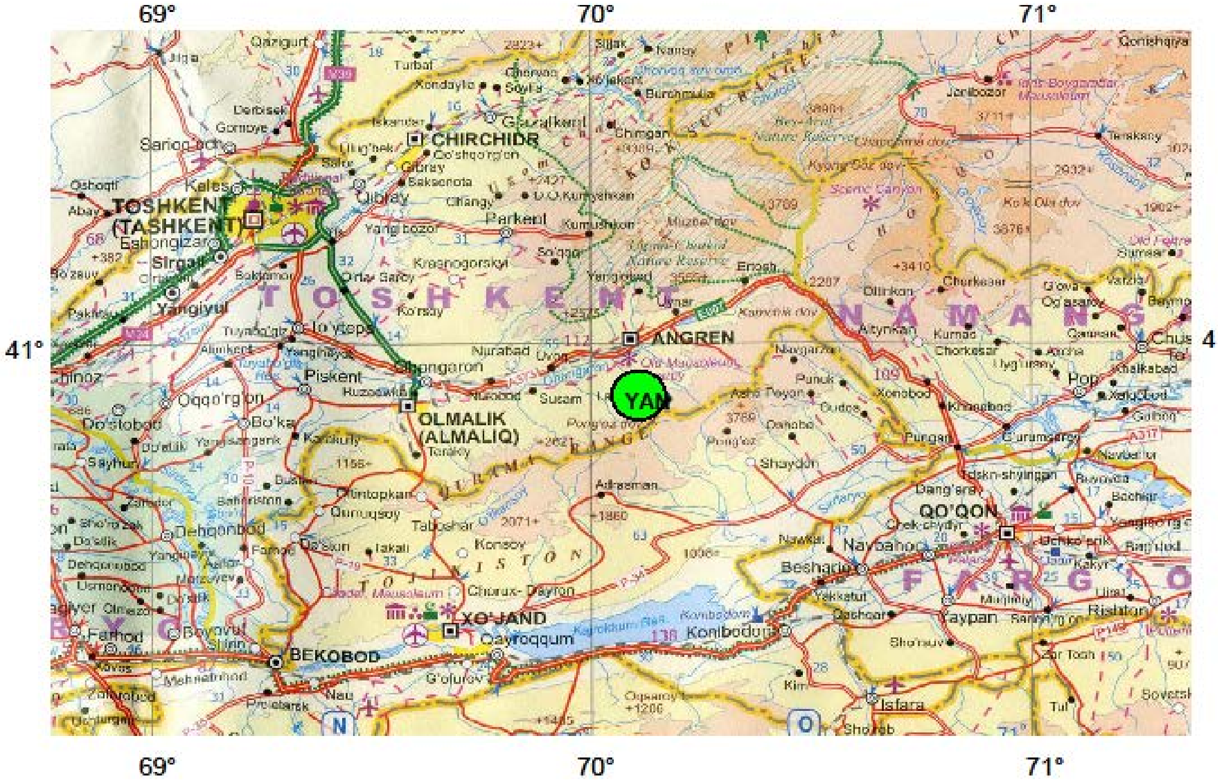
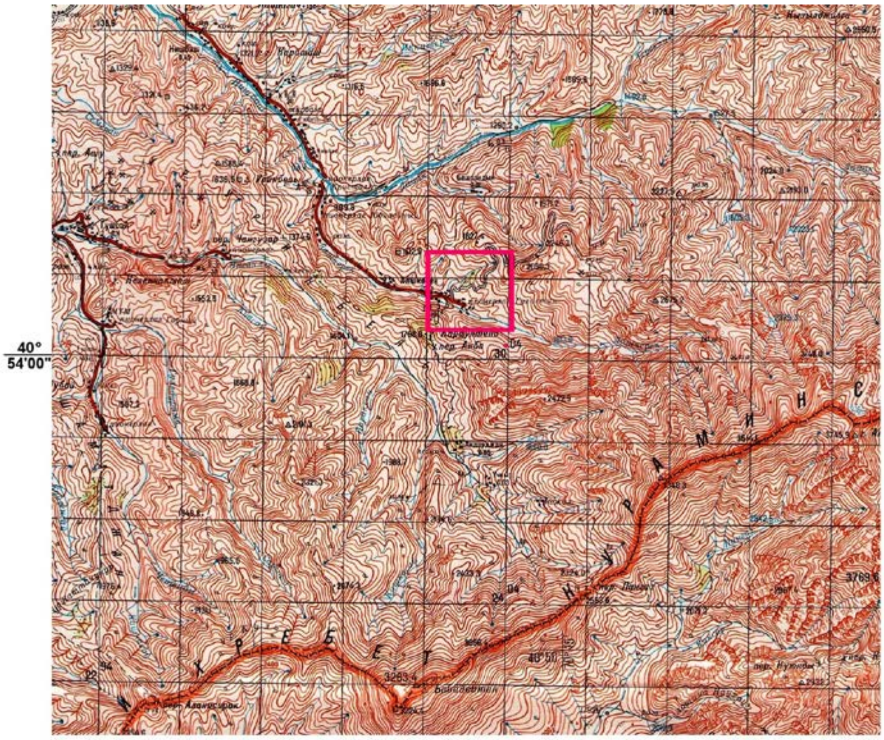


Fig 2.1. Map of Yangonkli-Sai site.



1 : 100 000

Fig. 2.2. Geographical position of the YAN reference area.

Tab 2.1. Elevation and GPS coordinates for the YAN reference area.

Macro plot	Elevation (m asl)	N	E
1	1563	40°54.994′	070°13.325′
2	1596	40°54.990′	070°13.382′
3	1556	40°55.089′	070°13.392′
4	1570	40°55.062′	070°13.465′
5	1611	40°55.043′	070°13.508′
6	1627	40°55.043′	070°13.548′
7	1680	40°55.072′	070°13.572′
8	1620	40°55.073′	070°13.631′
9	1633	40°55.074′	070°13.656′
10	1635	40°55.137′	070°13.598′

2.2. Forest type, ownership and conservation status

The Yan reference site is located on the territory of the Ahangaran forestry enterprise which is included in the organization structure for Ugam-Chatkal State National Park, in turn subordinated to the Tashkent Regional Khokimiyat.

The Ahangaran forestry enterprise is a part of the Ugam-Chatkal State National Park organization, responsible for forest management. The main purpose for the establishment of this forestry entity was to provide protection of forests and forest biodiversity, to increase forest-covered areas through natural regeneration and forest plantations, to increase forest productivity, and to ensure effective use of non-wood forest products.

The forests in this area are dominated by two species of juniper; *Juniperus seravschanica* and *J. semiglobosa.* A third juniper species, *J. turkestanica,* is rather rare and is found only in the upper mountain zones.

According to the forest classification system of Uzbekistan, the juniper forests belong to Category 1, which means that they play an important role in water-protection, water-regulation and soil-protection.

2.3. Geology, topography and quaternary deposits

Based on surface characteristics, sedimentology and the general direction of the mountain ridge, a part of Western Tien Shan is treated as an independent natural complex and geographical district named Middle-Syrdarya.

The topographical structure of this area is closely connected to the history of the development of Western Tien-Shan. At the end of Paleocene most part of this region was covered by sea which in the beginning of the Superior Oligocene was completely receded. The land was leveled and covered by deposits. During this period the tectonic movements that mark the beginning of the Alpine folding and the occurrence of the basic folded structures, anticlinal raisings and synclinal valleys, begun to develop. From the end of Oligocene and during all Neocene and Quaternary periods, clastic material drifted from surrounding anticlinal raisings and accumulated in intermountain depressions and on bottom-mountain plains. The most recent tectonic movements resulted in mountain forming processes with the accumulation of eroded material in the lower parts.

One major factor in the formation of landscape structure is the mountain drainage. The differentiation of landscapes is also influenced by drifting and accumulation of clastic material.

2.4. Climate

The climate in the area is strongly continental, and the climatic conditions are related to the latitude, remoteness from oceans, and the complex orography. During winter the climate is influenced by dry and cold air coming from the north. The climate is also influenced by relatively warm and damp air coming from the Mediterranean, Black and Caspian seas and the summer climate is characterized by intensive radiation and low precipitation.

The growth period is moderately hot dry in the foothills belt and low mountains. In the middle elevation mountain zones, the growth period is moderately hot damp (hydrothermal factor 0.5-0.75).

During winter the temperature normally reaches values from -20 to -25 ^{0}C, but with increasing altitude the temperature can get as low as -40 ^{0}C.

Tab. 2.2. Description of climatic conditions (data from the meteorological station “Ablyk”)

Indicators	Unit	Value	Date
Average annual temperature	°C	12,6	
Absolute maximum temperature	°C	42	
Absolute minimum temperature	°C	-32	
First frosts	Days		29/X
Last frosts	Days		31/III
Duration of frost-free period	Days	210	
Annual precipitations	Mm	408	
Maximum relative humidity	Mm	67	January
Minimum relative humidity	Mm	28	July
Quantity of days with relative humidity ≤ 30%	Days	90	September
Snow cover, min.	Cm	15-20	November, December
Snow cover, max.	Cm	150 and more	November, December
Mean date of first snow cover	Days		20/XI
Mean date of snow cover melting	Days		12/III

The prevailing winds in the area come from North. Wind velocities are insignificant – 1.2-1.7 m/sec and the number of days with strong winds (more than 15 m/sec) averages to 3 days per year.

2.5. Vegetation zones and sections

In the lower part of the mountainous zone (1500-1800 m a.s.l.), juniper woodlands covered by wheatgrass predominate. Besides the dominating grass species, *Agropyron trichophorum,* meadow-forest graminoids occur on the northern exposure slopes such as *Bromus inermis, Dactylis glomerata, Poa nemoralis,* herbs such as *Astragalus angrenii, Dicthamnus angustifolia, Galium pamiroalaicum, Hypericum scabrum, Hypericum perfoliatum* and *Inula grandis.*

Typical for the medium-altitude region of the Kuramin range (1800-2200 m a.s.l.) are juniper communities with predominance of large grasses in the lower layer - *Dactylis glomerata, Eremurus sogdianus, E. turkestanica, Ferula tenuisecta* and *Prangos pabularia*.

2.6. Forest history, structure and external influence

The forests located on the territory of Ahangaran forestry enterprise were first inventoried in 1897 by the forest warden Navrotsky, who gave the first general description of the forest areas of the forestry enterprise. As a result of this work the forest sites were mapped. It was the first cartographical material of the forestry enterprise.

The subsequent work on forest stands in the area was carried out in 1924 - 1926. This work aimed basically at separating and bordering the State Forest Fund lands from public lands, and thereafter carrying out the forest inventory. The field inventory was carried out using simple tools and thus big blunders (discrepancies) were done. The forest inventory was carried out visually and no pilot plots were established.

The subsequent forest inventories were carried out in 1931, 1950, 1977 and 1987 according to revised versions of forest inventory protocols.

The area of the forestry enterprise defined during the forest inventory in 1987 made up 141,200 ha. Moreover, the area of the forestry enterprise defined by the recent forest inventory made up 183,466 ha, i.e. it has increased by 42266 ha.

The investigated area is under the influence of air pollution from several factories in the Angren corridor (petro-chemical, electricity production and metallurgic industry). Around 5 years ago the first signs of reduced vitality and damages on trees were observed. Close to Yangokli-San is the Umalak-Teppa site, established as a site in the TEMP-CA project in 2008 (Økland et al 2011). Yan is considered to have the highest degree of damage on trees of the two sites.

The Yan site is strongly influenced by human activities; overgrazing followed by soil erosion, trampling by humans and domestic animals, pruning and cutting of branches of trees for fire wood and fruit tree production.

3. FOREST STATUS AND TREE CONDITION

Gulusa Vildanova, Tor Myking, Tonje Økland, Nurlan I. Kasymbaev, Abdugappar Sharohmatov and Karl H. Thunes

3.1. Methods

3.1.1. SAMPLING DESIGN

The establishment of monitoring plots and field assessments were done in accordance with the ICP-Forest manual (ICP Forests 2006), revised for Central Asian conditions. Briefly, at each site ten 30x30 m plots were established in which the spatial coordinates for all trees > 5 cm DBH (vitality trees) were assessed. The individual trees were numbered consecutively at breast height within each plot for later reassessments.

Within each of the plots a central macro plot of 10x10 m wais defined, in which more intensive assessments were done, such as measurement of tree heights, crown projections, and crown heights.

3.1.2. TREE PARAMETERS

At each site standard crown condition parameters, such as social status, defoliation, and discoloration were recorded. The classification of the defoliation follows ICP-Forest: Class 0 shows healthy trees, with ≤ 10% defoliation; class 1, ”warning stage”, > 10 up to 25%; class 2, “moderately damaged”, > 25-60%; class 3, “severely damaged”, > 60% defoliation; and class 4, dead trees. The assessment of defoliation did not consider dead trees, trees heavily damaged by abiotic factors, or greatly suppressed trees referred to class 4 by Craft’s classification.

Diameter at breast height was recorded for all trees > 5 cm DBH, whereas tree height was only recorded within the central 10x10 m macro plot (cf. ICP Forests 2006). To take into account possible non-circular stem circumference, the diameter at breast height of all vitality trees was assessed in two directions, north-south and east-west.

In addition, regeneration (< 5 cm DBH) of all tree species were recorded as a part of the ground vegetation analysis in the five 1-m^2 plot in each of the 10x10 m macro plots, making a total of 50 m^2 for the each site.

3.2. Results

3.2.1. COMPOSITION

The forest of the Yan reference site is dominated essentially by one species, *Juniperus seravschanica* (98.7%). In addition, there are a few trees of *Prunus sogdiana* present.

3.2.2. TREE CONDITION

Defoliation for *Juniperus seravschanica* was 38.0%, which is a notable level according to the ICP Forests classification. The proportion of discolorated trees, on the other hand, was only 1.3%.

3.2.3. DEMOGRAPHY AND REGENERATION OF MAIN SPECIES, *J. SERAVSCHANICA*

A high proportion of the *J. seravschanica* trees belonged to the three smallest size classes, while the number of individuals decreased with increasing DBH > 35 cm (Fig. 3.1). The two smallest size classes (DBH < 25 cm) represented 50.7% of the trees, but the size distribution was also characterized by the high proportion of trees in the intermediate size class (23.4% at DBH 25-35 cm). No saplings of *J. seravschanica* were recorded in the 1m^2 ground vegetation monitoring plots.

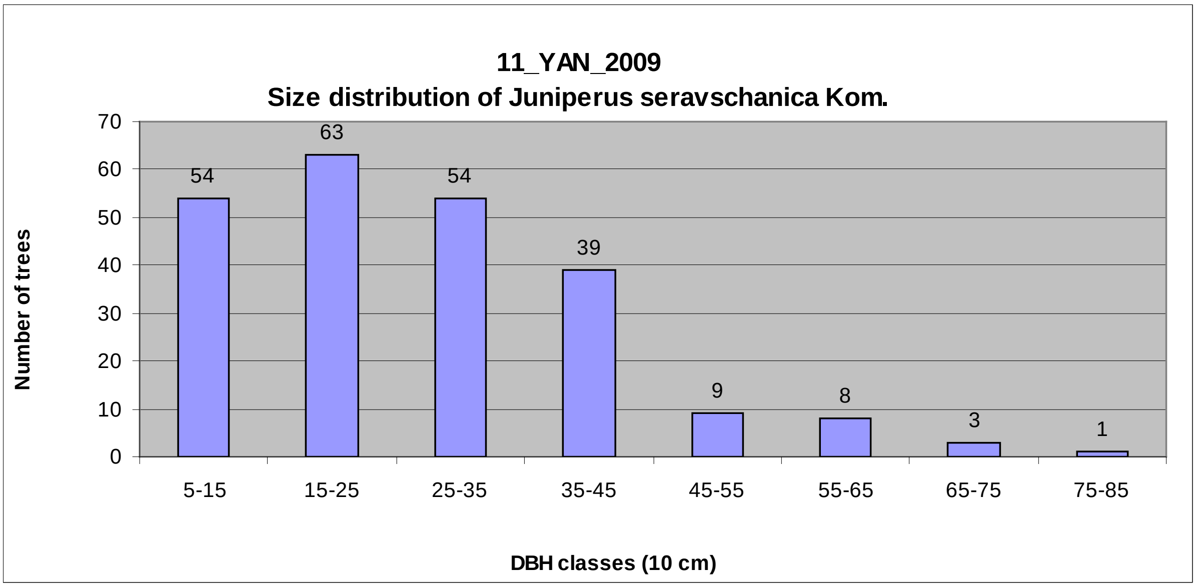


Fig. 3.1. Size distribution of *J. seravschania*.

3.3. Discussion

The forest condition was assessed using defoliation and discoloration of needles and leaves as the main indicators. Natural environmental factors such as climate and soil condition are known to be important for the forest condition. In addition, pest outbreaks, airborn pollution, water supply, grazing and cutting of firewood affect both regeneration and susceptibility to diseases. Thus, forest condition is determined by a number of natural and often anthropogenic factors, which implies that it could be difficult to single out the possible effect of pollutants for tree vitality at a given site.

The average defoliation of *Juniperus seravschanica* was 38%, which is in the moderately damaged range, 4 percentage points higher than in the neighbouring site at Umalak Teppa. At the same time the frequency of discolorated trees was very low. One reason for the discrepancy between the level of defoliation and discoloration may be that discoloration preceded defoliation, and that the discolorated needles already were shed at the time of the assessment.

Sufficient regeneration is fundamental for sustainable forests. According to the size distribution of *J. seravschanica*, a high proportion of the trees was found among the two smallest size classes (< 25 cm DBH), which is commonly the case. An astonishing deviation from the normal reversed J-shaped distribution curve, however, is the large intermediate size class (DBH 25-35 cm). This could be related to forest history, with one possibility that regeneration was greatly constrained in the past, but has more recently been allowed to grow up. Alternatively, the size distribution reflects that the present regeneration is hindered and deficient. Despite the total dominance of *J. seravschanica* in the tree layer, no saplings (< 5 cm DBH) were recorded in the ground vegetation plots. This lack of regeneration stresses the importance of specific monitoring of regeneration as well as reflects the grazing impact by the livestock present in the area.

4. BOTANICAL DIVERSITY AND GROUND VEGETATION

Adilet K. Usupbaev, Igor Belolipov, Tonje Økland, Kuvanychbek S. Kasiev and Odd Eilertsen

4.1. Methods

The sampling design and methods follow the Norwegian concept for forest ground vegetation monitoring (Økland 1996, Lawesson et al. 2000; see also Liu et al. 2008).

The key principles are summarised below:

(1) Study areas should be selected to represent the regional variation within the entire area of interest (for example region or a country), the intensity of impact factors (for example airborne pollutants), as well as climatic and other broad-scaled environmental gradients.

(2) Similar ranges of variation along all presumably important vegetation and environmental gradients within the pre-selected habitat type should be sampled from each study area, in similar ways.

(3) Ground vegetation, tree variables, soil variables, and other local environmental conditions of importance for the vegetation should be recorded in the same, permanently marked plots.

(4) Identification and understanding of the complex relationships between species distributions, the total species composition, and the environmental conditions in each study area form a necessary basis for interpretation of changes in ground vegetation, and for hypothesising relationships between vegetation change and changes in the environment.

(5) Observed changes in nature caused by anthropogenic factors not of primary interest for the monitoring study may interfere with and obscure trends related to the factors of primary interest. The influence of such factors should be kept at a minimum, for example by selecting areas in near-natural state.

(6) The sampling scheme must take into consideration the purpose of the monitoring and meet the requirements for data analyses set by relevant statistical methods which imply constraints on plot placement, plot number and plot size.

(7) All plots should be re-analysed regularly. For most forest ecosystems yearly re-analyses will impose too much trampling impact etc. to be consistent with the purpose of monitoring. The optimal time interval between re-analyses in different ecosystems may vary among ecosystems.

4.1.1. SAMPLING DESIGN

The following sampling scheme have been used for monitoring in each of Central Asian monitoring reference areas: Ten macro sample plots, each 10x10 m were placed subjectively in order to represent the variation along presumably important ecological gradients; in aspect, nutrient conditions, light supply, topographic conditions, soil moisture, etc. Each of the ten 10x10 m sample plots was positioned in the centre of one 30x30 m plot, to be used for recording of tree parameters. All plots were confined to one catchment area. All 10x10 m plots should allow placement of 1-m^2 plots in at least 20 of the 100 possible positions. Five 1m^2 sample plots were randomly placed in each macro sample plot.

As far as possible, sites that were not visibly affected by external impacts were preferably chosen for placement of macro plots. Sample plot positions were rejected according to a predefined set of criteria. Positions for 1m^2 plots were rejected if they (1) had a joint corner or side edge with another plot; (2) included trees and shrubs or other plants that physically prevented placement of the aluminium frame used for vegetation analysis of the plot; (3) were physically disturbed by man (by soil scarification, extensive trampling or crossed by a path, digging of pits, etc.); (4) were disturbed by earth slides; (5) were covered by stones for more than 20% of their area; or (6) when a vertical wall of 25 cm or more would be included or situated close to the corresponding plot. In case of rejection, a new position for the $1m^2$ plot was selected according to a predefined set of criteria. All plots were permanently marked by subterranean aluminium tubes as well as with visible plastic sticks.

4.1.2. VEGETATION PARAMETERS

Frequency in subplots was used as the main species abundance measure. Each of the fifty $1m^2$ plots was divided into 16 subplots, 0.0625 m^2 each. Presence/absence of all species was recorded for each of the subplots, and frequency in subplots was calculated for each species in each $1m^2$ plot. A species was recorded as present when it covers a subplot (Fig. 3.1). In addition to frequency in subplots, visual estimates of *percentage cover* was made for each species in each plot, since this additional information are obtained with very little extra time consumption.

All species present in the ten 10x10 m plots as well as 30x30 m plots were listed.

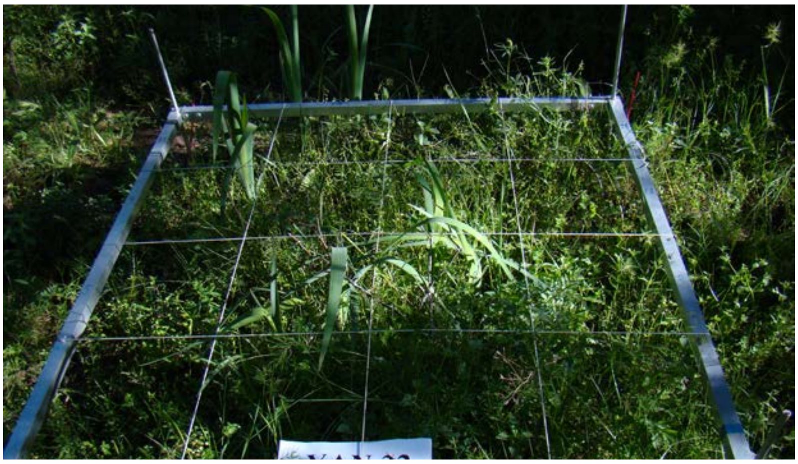


Fig. 4.1. Typical vegetation plot in Yangonkli-Sai. Photo: Tonje Økland.

The number of vascular plant species within macro plots was calculated as: (a) the cumulative number of species recorded within the five $1m^2$ plots in each. 10x10 m macro plot, (b) the total number of species recorded in each 10x10 m macro plot, and (c) the total number of species in each 30x30 m extended macro plot. The ratio a/b and a/c was calculated for each macro plot.

4.1.3. EXPLANATORY PARAMETERS

Explanatory variables are environmental and other variables we use for interpretation of vegetation gradients; i.e. relationships between these variables and species composition along gradients. These variables all influence the ground vegetation by influencing the species composition along gradients and biodiversity, in different ways and to variable degrees. Explanatory variables are partly measured at field work, partly measured at laboratory by analyses of soil samples and partly calculated based on measured variables.

Several explanatory variables, of five main types were measured/calculated: (1) topographical; (2) tree influence; (3) soil physical; (4) soil chemical; and (5) grazing variables.

(1) Topographical variables include:

Inclination was measured in a way that is representative for each $1m^2$ plot by a clinometer compass.

Aspect un-favourability can be expressed as deviation of the recorded aspect measured representative for each $1m^2$ plot by use of a compass (0-360º) from SSW (202.5º). In the northern hemisphere, SSW is considered to be the most favourable aspect (Heikkinen 1991) due to high incoming radiation at times of day with high temperatures. However, it is more suitable for statistical analyses to recalculate to *aspect favourability*; thus we recalculated the values according to this formula:

ABS[180-ABS(202.5-aspect value)]

From the values of inclination and aspect we calculated the heat index (Parker´s index; Parker 1988) as:

COS(202.5-aspect value)*TAN(inclination value)

Indices of *concavity/convexity* in each $1m^2$ plot were calculated by assigning to each plot an index value for concavity/convexity of each subplot on the following scale: –2 (concave), –1 (slightly concave), 0 (plane),1 (slightly convex), 2 (convex). The same scale was used for the 9 subplots in a 3x3 m plot with the $1m^2$ plot in centre. Derived indices were calculated for both the $1m^2$ plots and for the 3x3 m plots by (a) summarizing the values, (b) summarizing the absolute values and (c) calculating the variance.

Maximum inclination was measured by a clinometer as the maximum measurable slope between two points in the sample plot, situated 10 cm apart.

(2) Tree influence variables include:

- Crown cover index
- Litter index
- Basal area

All trees that were (i) rooted within the macro plot; (ii) rooted within a 2-m buffer zone bordering on the plot; or (iii) covering the plot or the buffer-zone, were marked with numbers, in the field and on a sketch map of each macro plot with positions of the $1m^2$ plots, canopy perimeters and tree stems drawn in. *Crown area* for each tree, **cai**, i.e. the area within the vertical projection of the crown perimeter, was estimated from the sketch maps. The *tree heights* were measured in dm from normal stump height to the tree top and the crown heights were measured as the difference between total tree height and the distance from the ground to the point of the stem where the lowest green branch whorl (i.e. the lowest green branch whorl which is separated from the rest of the crown by less than two dry branch whorls) emerged. *Crown cover*, **cci**, is estimated as the percentage of the crown area (visible from below) covered by living phytomass.

Crown cover index was calculated by use of crown area, **cai,** and crown cover, **cci** for all trees i = 1,...,n covering inside a 25 m^2 (5x5 m) plot around each $1m^2$ plot (the $1m^2$ plot placed in the centre of the 25 m^2 plot):

$$CC = \sum_i \mathbf{cai} \cdot \mathbf{cci} / 25$$

Litter index is calculated by modifying the index of Økland (1990, 1996) and Økland & Eilertsen (1993):

For each tree, the part of the crown area which is inside the $1m^2$ plot, **ca**, is measured and a line is drawn on the sketch map from the stem centre through the centre of the plot.

Four different cases were distinguished, the first three relating to trees with the stem centre within the crown perimeter, the fourth addressing eccentric trees.

(i) The line has one point of intersection with the sample plot margin within the crown perimeter (it intersects the crown perimeter once within the plot). This is the most usual case.

A distance **di** measured along the line from its point of intersection with the crown perimeter to the sample plot border (within the crown perimeter), *crown radius,* **cri** measured along the line as the distance from the stem centre to the line's intersection with the crown perimeter, the fraction of the crown area that is inside the $1m^2$ plot, **cai**; *crown cover*, **cci**; crown height, chi; tree height, **hi,** were used to calculate the litter index.

The contribution of a tree i to the litter index is:

LitterIi = (di / cri) × cci × cai × (hi - chi)

The litter index for each $1m^2$ plot was calculated as:

LitterI = ∑i (di / cri) × cci × cai × (hi - chi)

(ii) The line intersects the sample plot twice within the sample plot before intersecting with the crown perimeter (this may be the case for plots situated below large trees). A distance **di** measured along the line from its point of intersection with the crown perimeter to the proximal sample plot border (the border closest to the stem centre), crown radius**, cri** measured along the line as the distance from the stem centre to the line's intersection with the crown perimeter, the fraction of the crown area that is inside the $1m^2$ plot**, cai;** *crown cover*, **cci**; crown height, **chi,** and tree height, **hi** were used to calculate the index.

The contribution of a tree i to the litter index and the litter index for each $1m^2$ plot were calculated with the same formulas as above.

(iii) The tree crown covers a minor part of the plot only, and the line intersects the sample plot margin outside its point of intersection with the crown perimeter. The contribution to the litter index is by definition set to zero; **LitterI = 0**

(iv) Eccentric trees (rooted outside the crown perimeter). The contribution of eccentric trees is calculated as:

LitterIi = cci × cai × (hi - chi)

The litter index for each $1\text{-}m^2$ plot was calculated as:

LitterI = ∑i cci × cai × (hi - chi)

Basal area (relascope sum) is an expression of tree density on a relatively broad scale around each measurement point, i.e. the complement of light supply to the understory. Basal area was measured at breast height by use of a relascope from the corner of each $1m^2$ sample plot.
We calculate:

(1) The relascope sum for coniferous trees
(2) The relascope sum for deciduous trees
(3) The sum of (1) and (2)

(3) Soil physical variables include:

- *Soil depth*; calculated by measurement of the distance a steel rod can be driven into the soil in fixed positions, 10-15 cm outside the plot border, eight single measurements are made for each plot. Minimum, maximum, and median values were calculated for each plot.

- *Depth of organic layer*; measured at four fixed points for each plot. Minimum, maximum, and median values were calculated.

- *Depth of litter layer* was measured in five fixed points within each 1m^2 plots. Minimum, maximum, and median values were calculated.

- *Estimations of % cover of litter*.

- *Loss on ignition* (gravimetric loss after combustion, determined by ashing ca.1 g of sample at 550 ℃ in a muffle furnace; for details, see method description for soil analyses Chapter 6).

- *Soil moisture* was determined for volumetric soil samples, collected from the upper 5 cm of the humus layer. The samples were collected about 10 cm from the border of each meso plot, whenever possible below the plot. All samples from one reference area were collected on the same day, preferably after a period of some days without rainfall, with the aim of representing median soil moisture conditions, i.e. the normal soil moisture at the site (cf. Økland 1990, Økland & Eilertsen 1993). The samples were stored in paper bags kept inside double plastic bags and kept frozen until they were weighed in the laboratory. After drying at 110 °C to constant weight, the samples were weighed again and percentage moisture was calculated.

(4) Soil chemical variables include:

- *pH measured* in aqueous *solution*,
- *pH measured in* $CaCl_2$

- the content of *loss on ignition, organic C, total N* and *P-AL* and *exchangeable acidity* concentrations and the cations *Ca*, *Mg*, *K*, *Na*, *Al*, *Fe*, *Mn*, and *Zn, among others.* For detailed method descriptions; see Chapter 5.

(5) Animal impact variables include:

Some of the factors could be measured directly in the 1m^2 plot, e.g. grazing intensity and % cover animal manure/dung. Other factors must be found by interviews of locals, e.g. *date/period of scything/hay-making* for the area and/or macro plot and *grazing period* (time period for grazing by horses, cows, goats, and sheep). Parameters measured directly in field descriptions/estimation values for:

-Domestic animal grazing condition
-Grazing intensity
-Average grass height
-Average herb height
-% cover animal manure/dung
-% cover animal traces/footprints
-% cover animal tracks
-% browsing damage on woody plants for each species
-% cover of wild animal holes

Short descriptions of the *domestic animal grazing condition* and *scything/hay-making condition* and *wild animal grazing conditions* (grazing/browsing/digging) were given for each 1m^2 plot.

Grazing intensity: Estimations were made for each 1m^2 plot on a subjective scale with 4 levels: 0 = no grazing indications; no indications of grazing on the vegetation were seen. 1 = some grazing (patchily grazing); spots that were highly grazed and other spots that were not grazed could be seen. 2 = even grazing; even/plane grazing had removed much of the grass and herbs in the plot. 3 = extreme grazing (< 5 cm vegetation height); most of the grass- and herb-layer had been grazed and the field layer was very low, often below 5 cm.

Average grass height: The average height of the grass-cover in cm was measured for each $1m^2$ plot with a measuring rule.

Average herb height: The average height of the herb-cover in cm was measured with a measuring rule.

% cover animal manure/dung: The percentage cover of domestic animal dung/manure in the plot was estimated.

% cover animal traces/footprints: The percentage cover of domestic animal footprints in the plot was estimated.

% cover animal tracks: The percentage cover of domestic animal tracks in the plot was estimated.

Browsing damage on woody plants: A short description of the domestic browsing on each of the woody plants that were browsed upon by domestic animals was given: Species; name of the woody plant, s*tem%;* how much of the stem in % that are browsed, shoots*;* how many of the shoots that approximately have been browsed.

% cover of wild animal holes: Estimations of the percentage cover of traces and digging holes made by wild animals were performed for each $1m^2$ plot.

4.1.4. ORDINATION METHODS

Species abundances with a frequency lower than the median frequency (in the set of all species) were down-weighted by multiplying for each species the recorded abundances with the ratio of this species' frequency and the median frequency (Eilertsen et al. 1990) before ordination analyses.

Ordination methods are used to summarize the main gradients in the vegetation of the sample plots. DCA (Detrended Correspondence Analysis; Hill 1979, Hill & Gauch 1980), one of the most common used multivariate statistical methods, was performed on subplot frequency data on 50 plots by means of CANOCO Version 4.54 (ter Braak & Šmilauer 1998), which are debugged according to Oksanen & Minchin (1997). Standard options were used (i.e. no down-weighting of species, nonlinear rescaling of axes and detrending by segments).

4.1.5. INTERPRETATION OF GROUND VEGETATION GRADIENTS

Ordination axes express vegetation gradients. In order to elucidate the complex relationships between species composition and environmental conditions, these gradients were interpreted by means of the measured environmental variables. The interpretation of DCA ordination was performed by calculating Kendall's rank correlation coefficient τ between plot scores along DCA axes and environmental variables.

4.2. Results

4.2.1. BOTANICAL DIVERSITY

The number of species, α-diversity, are reported in this chapter, while β-diversity (variation in species composition along gradients) will be reported in chapter 4.2.2 below. The total species list is given in Appendix 2.2. The number of species within macro plot was calculated as the sum of species in the five 1m^2 plots in each 10 x 10 m macro plot (a), as the total number of species in each 10x10 m macro plot included the species in the 1m^2 plots (b), and as the total number of species in each 30x30 m extended macro plot included the species in the 1m^2 plots (c, Tab. 4.1). The ratio a/b and a/c was calculated for each macro plot. All together 78 species was recorded in the 50 1m^2 plots. Of these species 13 are endemic to Central Asia: *Arum korolkovii, Carex turkestanica, Cousinia olgae, Eremurus regelii, Euphorbia jaxartica, Pedicularis krylovii, Galium pamiroalaicum, Gymnospermium alberti, Iris sogdiana, Prunus sogdiana, Rosa kokanica, Thalictrum sultanabadens* and *Veronica bucharica.*

The maximum number of species recorded in any 1m^2 plot (bryophytes included) was 15 while the minimum number was 3 and the average number was 9. The total number of vascular plant species recorded within the 50 1m^2 plots + ten 10x10m^2 plots was 87. The total number of vascular plant species in the in the 50 1m^2 plots + ten 30x30m^2 plots was 98. The maximum number of species recorded in any of the 10x10 m macro plots (the five 1m^2 plots included) was 26 and the minimum number was 21. The average number of species in the 10x10 m macro plots (the five 1m^2 plots included) was 27. The ratio a/b varied between 0.77 and 0.95 (Tab. 4.1). The ratio a/c varied between 0.67 and 0.84 in the macro plots.

The plant species were divided into species groups, tree species and shrubs, ferns, graminoids, bryophytes and lichens (Tab. 4.2).

Tab. 4.1. Total number of vascular plant species in five 1m^2 plots (a), five 1m^2 plots + 10x10 m macro plot (b), five 1m^2 plots + 30x30 m extended macro plot (c), and ratios a/b and a/c.

Plot number	a Five 1-m^2 plots	b Five 1-m^2 plots + 10x10 m plot	c Five 1-m^2 plots + 10x10 m plot + 30x30 m plot	The ratio a/b	The ratio a/c
1	24	26	29	0.92	0.83
2	19	23	27	0.83	0.70
3	21	22	25	0.95	0.84
4	25	27	30	0.93	0.83
5	26	28	33	0.93	0.79
6	21	24	31	0.88	0.68
7	22	27	30	0.81	0.73
8	24	31	36	0.77	0.67
9	23	29	32	0.79	0.72
10	26	30	37	0.87	0.70
Total number	79	87	98	0.91	0.81

Tab. 4.2. Number of species in different species groups within each 10x10 m macro plot and in total.

Plot number	Tree species	Shrubs	Herbs	Ferns	Graminoids	Bryophytes	Lichens
1	0	1	20	0	3	4	0
2	0	0	17	0	2	3	0
3	0	1	14	0	6	0	0
4	0	1	21	0	3	1	0
5	1	2	20	0	3	1	0
6	0	2	17	0	2	1	0
7	1	2	17	0	2	4	0
8	0	1	20	0	3	5	0
9	0	1	20	0	2	2	0
10	0	0	21	0	5	0	0
Total number	**1**	**5**	**63**	**0**	**10**	**8**	**0**

4.2.2. MAIN GROUND VEGETATION GRADIENTS

DCA ordination of 50 plots is shown in Figs. 4.2-4.5. Gradient lengths; β-diversity, and eigenvalues for DCA axes 1-4 are given in Tab. 4.3.

Tab. 4.3. Eigenvalues and gradient lengths for DCA of 50 plots.

	DCA 1	DCA 2	DCA 3	DCA 4
Eigenvalues	0.744	0.413	0.234	0.157
Gradient lengths	5.781	3.954	2.296	2.324

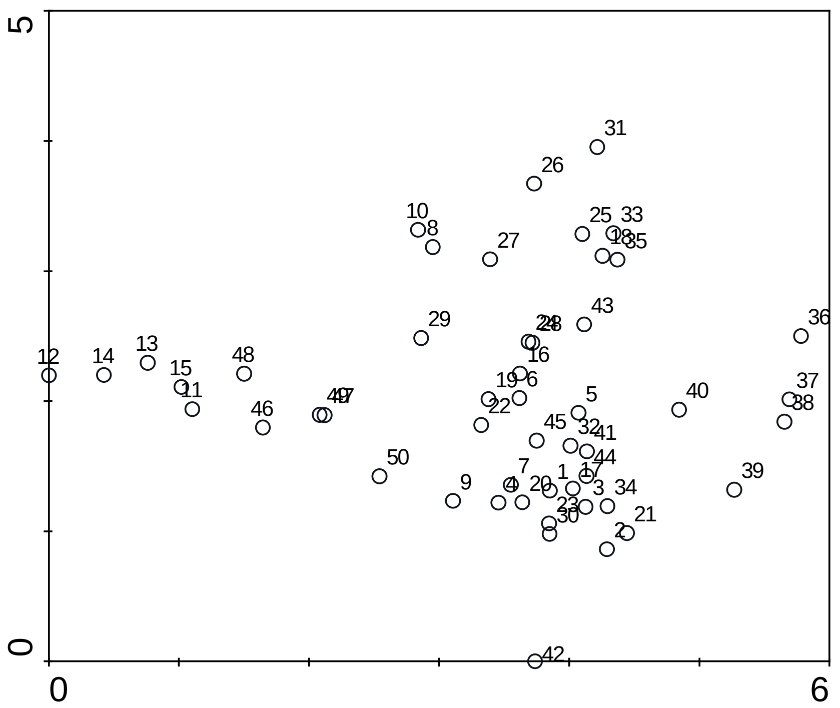


Fig. 4.2. DCA ordination of 50 1m^2 plots, axes 1 (horizontal) and 2 (vertical). Plot numbers for the 50 1m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

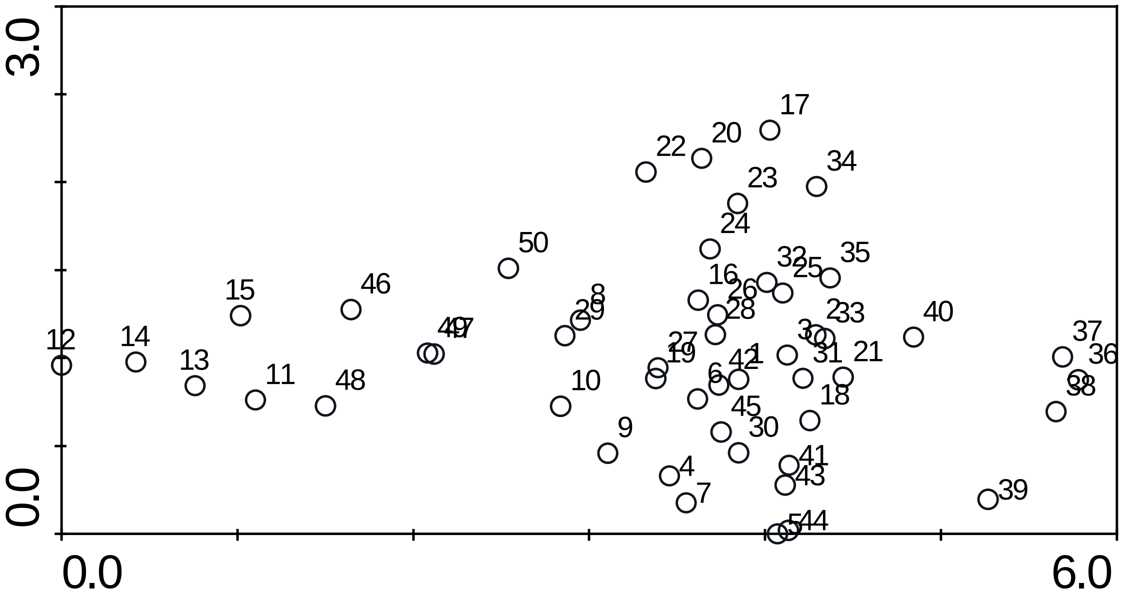


Fig. 4.3. DCA ordination of 50 1m^2 plots, axes 1 (horizontal) and 3 (vertical). Plot numbers for the 50 1m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

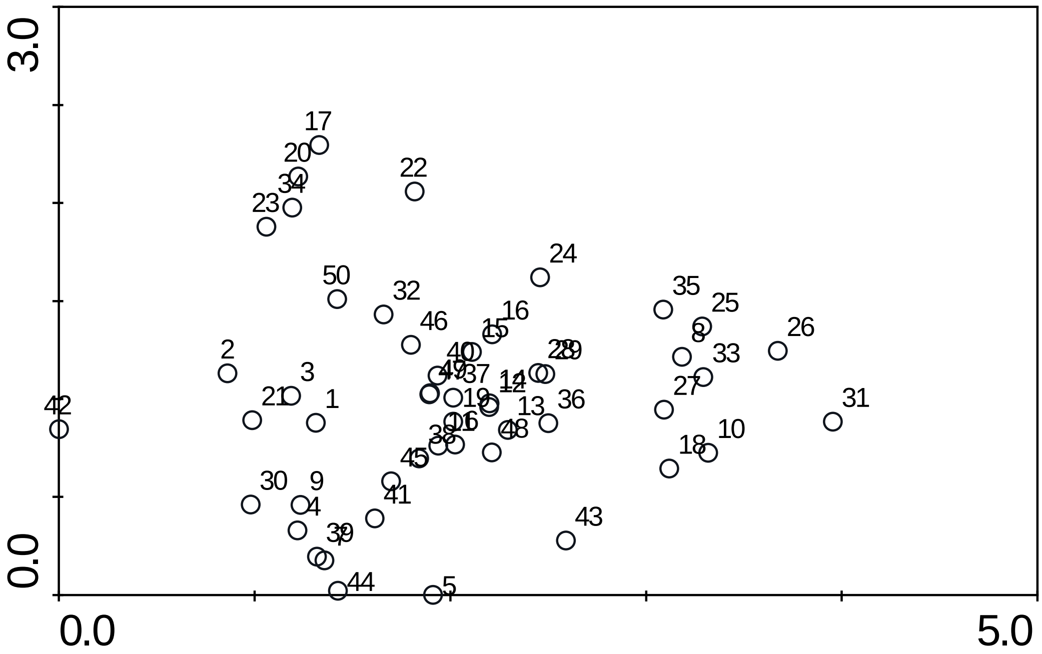


Fig. 4.4. DCA ordination of 50 1m^2 plots, axes 2 (horizontal) and 3 (vertical). Plot numbers for the 50 1m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

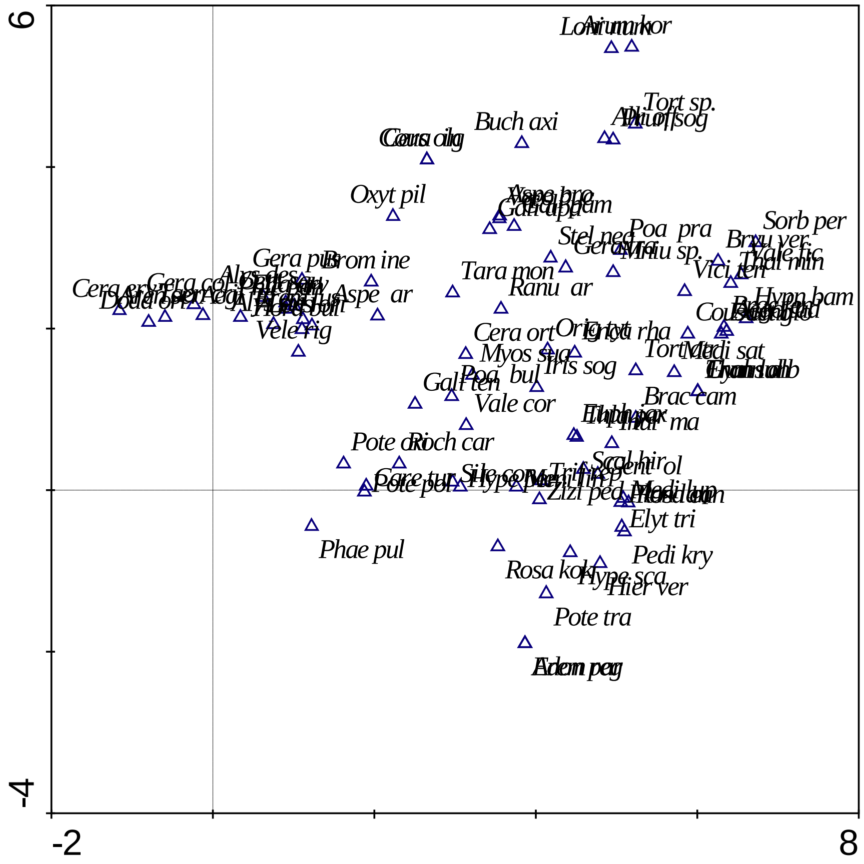


Fig. 4.5. DCA ordination of species in the 50 1m^2 plots.

4.2.3. CORRELATION BETWEEN EXPLANATORY VARIABLES AND DCA ORDINATION AXES

Kendall´s non-parametric correlation coefficient τ between DCA-axes and between DCA-axes and explanatory variables is shown in Tab. 4.4.

Tab.3.4. Statistically significant Kendall´s non-parametric correlation coefficient τ between DCA-axes and explanatory variables with P-values

Variable	DCA 1	P	DCA 2	P	DCA 3	P	DCA 4	P
Soil moisture	-0.345**	0.000					0.193*	0.047
Inclination	0.255*	0.011					-0.322**	0.001
Aspect	0.366**	0.000					-0.260**	0.008
Aspect fav	-0.406**	0.000					0.348**	0.000
Heat index	0.388**	0.000					0.400**	0.000
Max. incl.	0.219*	0.028					-0.293***	0.003
Sum conc. 3x3 m	-0.242*	0.019	0.239*	0.021				
Var. conc. 3x3 m			0.267**	0.009				
Abs. sum conc. 3x3 m			0.217*	0.037				
Relascope decid. trees	0.279*	0.017			-0.300*	0.010		
Relascope conif. trees	0.216*	0.031					-0.338**	0.001
Relascope total trees	0.216*	0.031					-0.334**	0.001
Crown cover index			0.343**	0.001			-0.199*	0.042
Litter index			0.288**	0.005			-0.218*	0.034
Grazing intensity	-0.299*	0.011			0.488**	0.000		
Average grass height	0.431**	0.000			-0.303**	0.004	-0.243*	0.021
% cover animal traces/footpr.					0.457**	0.000		
% cover animal tracks			0.236*	0.041				
Max soil depth	0.432**	0.000					-0.275**	0.006
Min soil depth	0.458**	0.000					-0.293**	0.003
Med soil depth	0.374**	0.000					-0.250*	0.011
Max. org. layer depth	0.330**	0.001			0.242*	0.018	-0.203*	0.046
Min. org. layer depth	0.379**	0.000					-0.219*	0.032
Med. org. layer depth	0.320**	0.001					-0.234*	0.018
Max. litter depths	0.283**	0.009					-0.258*	0.018
Min. litter depths	0.209*	0.047					-0.253*	0.016
Med. litter depths							-0.255*	0.016
Altitude	0.198*	0.050						
pH			-0.434**	0.000			0.282*	0.012
H+			0.434**	0.000			-0.282*	0.012
Dry matter %	-0.265*	0.034						
LOI	-0.269*	0.014	0.379**	0.001			-0.313**	0.005
Ctotal%	-0.285**	0.010	0.379**	0.001			-0.292	0.008
Mg	-0.288**	0.010						
Na			0.290**	0.009				
Total N, mkg/g	-0.464**	0.000					-0.232*	0.036
PO4 mg/kg	-0.221*	0.050	0.404**	0.000				
Ca, ppm			0.235*	0.035			-0.253*	0.023
Mg, ppm					0.339**	0.003		

Na, ppm					0.266*	0.018		
K, ppm					0.313**	0.006		
Al, ppm					0.282*	0.011		
Fe, ppm					0.246*	0.029		
Mn, ppm					0.263*	0.021		
P, ppm					0.252*	0.024	-0.234*	0.034
Zn, ppm	-0.319**	0.005						
Ca/LOI*100	0.267*	0.015	-0.351**	0.001				
Mg/LOI*100			-0.290**	0.009			0.249*	0.024
K/LOI*100							0.228*	0.038
CEC calc/LOI*100			-0.351**	0.001			0.228*	0.038
SO_4 water soluble	0.226*	0.040	-0.218*	0.048	-0,218*	0.048		
SO_4 acid solunble			-0.233*	0.034				
PO_4 mg/kg/LOI*100			0.223*	0.043				
Ca, ppm/LOI*100					-0.218*	0.048		
Mg, ppm/LOI*100			-0.272*	0.014				
Na, ppm/LOI*100			-0.300**	0.006				
K, ppm/LOI*100			-0.326**	0.003				
Al, ppm/LOI*100			-0.292**	0.008				
Fe, ppm/LOI*100			-0.349**	0.002				
Mn, ppm/LOI*100			-0.328**	0.003				
Zn, ppm/LOI*100			-0.305**	0.006				

4.3. Discussion

4.3.1. GENERAL DESCRIPTION OF VEGETATION AND GROUND VEGETATION BIODIVERSITY

The main dominating tree species of the juniper forests of Yangokli San is *Juniperus seravshanica*. The juniper (archa) forests typically have a mosaic distribution of grass-stands, where shade-requiring plants grow under crowns and steppe plants with a considerable number of ephemers inhabiting the inter-crown spaces.

Shrub species in the area includes among others *Arum korolkovii, Cerasus erythrocarpa, Lonicera nummularifolia, Rosa canina, Rosa kokanica* and *Sorbus persica.*

The grass and herb layer is dominated by *Poa bulbosa* and *Bromus inermis,* with the less dominant species *Origanum tythanthum, Thlaspi perfoliatum, Stellaria neglecta* and *Buchingera axillaris.* Other species typical for the area are *Alliaria petiolata, Galium aparine, Poa pratensis, Scalligera hirtula, Taraxacum montanum, Veronica bucharica, Hordeum bulbosum* and *Ceratocephalus orthoceras.* Many species endemic for Central Asia occur in the area.

4.3.2. INTERPRETATION OF GROUND VEGETATION GRADIENTS

This site is strongly influenced by human impact; overgrazing by domestic animals, grass mowing and even planting of almond and apple trees right at the border of the site. Some of the plots were in areas protected by a fence and was thus not so influenced by grazing, in other plots soil erosion due to overgrazing and trampling was severe. Also local pollution may influence the trees and ground vegetation in this area (see §9).

All of the topographical variables were relatively strongly and significantly correlated with DCA 1; *aspect favorability* was negatively correlated while *heat index*, *aspect*, *inclination* and *maximum inclination* were all negatively correlated. *Soil moisture*, *grazing intensity*, *% dry matter* and several soil chemical parameters (total concentration of Mg, N, Zn and C) were negatively correlated with DCA 1 while *soil depth parameters*, *grass height*, *Ca*, SO_4 and *organic* and *litter depths* were all positively correlated with DCA 1. These results indicate variation in species composition from sites with mainly southern *aspects* and relatively low *soil moisture*, high *soil depths*, high *depth of the organic soil layer*, high *litter depths,* high *grass heights*, little *grazing* and low total concentration of nutrients in soil to sites with more or less northern *aspects,* higher *density of juniper trees*, higher *soil moisture*, lower *soil depths*, *litter depths* and *depths of the organic soil layer* and higher contents of nutrients.

DCA 2 can be an inferred disturbance gradient as it correlates positively with factors related to animal activity, *animal tracks*, *C*, *Ca*, *Na* and PO_4. However, a nutrient gradient is just as likely represented by DCA 2 because pH and chemical elements related to plant nutrient demands were clearly correlated with this axis.

A stronger disturbance gradient, directly related to animal activity is shown with DCA 3 as grazing intensity and % cover of animal traces and footprints were strongly correlated with this axis. Moreover, most chemical elements had also a positive correlation with DCA 3. Some variables were also correlated with DCA 4, but most of them were more strongly correlated with other DCA axes.

Apparently the main variation in vegetation in this area is due to variation in pH, nitrogen contents, soil depth, animal activity and topography, followed by soil moisture, organic matter and grazing.

5. PATHOGENIC FUNGI

Halvor Solheim

5.1. Methods

A general assessment of defoliated juniper trees (*Juniperus seravschanica*) was done (see chapter 3). To assess the involvement of pathogenic fungi in crown defoliation of juniper trees were inspected for fruitbodies of rot fungi on stems and fruitbodies on dying and newly killed twigs and branches. Surveys were done 21th September 2009, 5th and 6th May 2010 and 13th September 2010. Samples of *Gymnosporangium* on juniper trees were taken in May samples were, while samples from the alternate hosts *Cotoneaster pseudomultiflora* and *Crateagus turkestanica* were taken in September. Fruitbodies of rot fungi were looked after any time. Samples of fruitbodies were taken in or near macroplots for microscopy and molecular analyses. For molecular analysis the ITS region was sequenced according to standard methods (Yun 2009). The achieved sequences were compared with sequences in the GenBank Sequence Database.

5.2. Results

The dominating problem for juniper trees is an ongoing shoot dieback which could be observed in all plots (see also Chapter 3). Several stages of the dieback were observed. It seems to start in the lower part of the crown on a few twigs or branches. Then it spreads to more branches and further up in the crown. A few trees were severely affected with less than 20% left of the foliage.

Dead or dying branches had quite often swellings similar to swellings caused by *Gymnosporangium* species attacking twigs of various juniper species worldwide. In May 2010 fruiting structure of *Gymnosporangium* sp. was found on swellings of newly infected twigs (Fig 5.1). Seven samples were sequenced. All were identical and comparison with available sequences in Gen Bank gave 98% similarity with *Gymnosporangium sabinae*.

Figure 5.1. A juniper twig infected with *Gymnosporangium*. On the swelling of the twig (right) fruiting structer of *Gymnosporangium* can be seen. The twig part out off the swelling will soon decline. Photo: Halvor Solheim.

Also in May 2010 small yellow spots of early damage of *Gymnosporangium* was found on leaves of a *Crateagus turkestanica*. The symptom was similar to damage caused by *G. confusum.* In September spots with well developed attacks caused by *G. confusum* were found on leaves of *C. turkestanica*. In addition spots caused by *G. fusisporium* were found on leaves of *Cotoneaster pseudomultiflora*.

On three living juniper trees fruitbodies of *Pyrofomes demidoffii* were found. On two of the trees the fruitbodies were found near branch stub (Fig. 5.2), and in one case it was found at the edge of a large wound.

Figure 5.2. Fruitbody of *Pyrofomes demidoffii* just below branch stub. Photo: Halvor Solheim.

5.3. Discussion

The dieback of juniper trees may have various causes, but attack by *Gymnosporangium* species seems to be of great importance. The importance of attack is difficult to predict since samples have not been taken during the main fruiting season for *Gymnosporangium* and no molecular studies have been done of dead or dying twigs/branches.

Gymnosporangium is a large rust genus with more than 50 species worldwide (Cummins & Hiraktsuka2003). Many of the species have the teleuto stage on junipers and the aecidium stage on species in Rosaceae. In Uzbekistan three species of *Gymnosporangium* on junipers are known; *G. turkestanicum* with the aecidium stage on *Sorbus* species, *G. fusisporium* with the aecidium stage on *Cotoneaster* species and *G. confusum* with aecidium stage on *Crataegus* species (Gulusa Vildanova, pers comm.). The aecidium stage of the two last mentioned species was found in the area, but no signs of *Gymnosporangium* were found on leaves of *Sorbus persica,* a tree species which seems to be rare in the area.

None of the three *Gymnosporangium* species have been sequenced so no sequences are available in GenBank. *Gymnosporangium sabinae*, which was closest when compared with sequences in GenBank, are a European and North-African species (Gäumann 1959). This species has also the aecidium stage on *Pyrus*, which was not found in the area.

Gymnosporangium species may affect juniper trees severely, mainly trees standing close to the alternate host. Juniper tree species may also be affected variously, and of the three *Juniperus* species in Uzbekistan *J. seravschanica* is most severely affected (Gulusa Vildanova, pers comm.). Generally, infections by *Gymnosporangium* are weather dependant needed warm and moist weather when spores are spread. If climate change gives longer periods with good condition for infection in the future the damage will increase.

Pyrofomes demidoffii causing Juniper pocket rot is a serious white heart rot fungus in living juniper trees. Generally it is a heart rot fungus which will hollow the trunk. Later on more and more of the sapwood will be affected and at its advance stage trees will die. This fungus infects mainly through wounds and pruning may be one of the primary entry sources as in North-America (Anonymus 2011). At least in this study both frutbodies were found adjacent to branch stubs left after pruning or a bark wound. The species is common in North- America and the high mountains in East-Africa, but rare in Eastern Europe and Central Asia

(Ryvarden & Gilbertson 1994). It is newly found in China as well (Dai & He 2009). Fruitbodies were only found on three trees, but it may be more frequent since many trees are pruned by the local population using branches of juniper as fire wood. Using an increment borer will disclose the frequency and how affected by the rot each infected tree is.

6. INSECTS

Karl H. Thunes, Abdugappar Sharohmatov, Abdujappar Sharomatov, Gulusa Vildanova and Halvor Solheim

6.1. Methods

Surveys for insect damage was done September 21, 2009 and a trap collections were carried out between May 6th – June 7th, 2010. Signs of defoliation in the Juniper canopies were initially assigned to three factors, i.e. pathogenic fungi (Chapter 5), air pollution (Chapter 9) or insect damage.

6.1.1. SAMPLING DESIGN

The first screening in September 2009 revealed significant insect damage on some of the Juniper tree trunks. It was, however, too late in the season to find live specimens so it was decided to try to collect insects in the active period by setting out flight-intercept traps (Fig. 6.1) baited with bark beetle pheromones.

Figure 6.1**.** Insect sampling with flight intercept traps. Photo: Karine Mirumyan

The fauna of this region is virtually unknown and we had no indication what to catch, thus four traps were baited with a cocktail of bark beetle pheromones as well as turpentine as a general attractant. The traps were mounted on May 6th, emptied every 3rd day and dismantled on June 7th, 2010. The beetles were preserved in 70% ethanol.

6.2. Results and discussion

No bark beetles were caught in traps. This does not imply that bark beetles are not present or active in this forest. A possible reason is that timing of the year for sampling was wrong or, more likely, that the pheromones had no effect on the beetles in the area. A longer time series of traps in addition to selective sampling will be required in order to confirm absence of bark beetles.

Some older signs which was could have been made by bark beetles, *Phloeosinus turkestanikus*, was seen on one cut branch. The indicator of bark beetles was that blue-stain fungi has been isolated from the wood. *P turkestanus* are active in late fall and early spring and adults were thus not present at the time of visits.

Major physical damage seen on some trees had an appearance similar to attacks made by longhorn beetles (Cerambycidae). Ants were present in the cavities, but we assume they were only secondary inhabitants. Adult beetles were not found.

6.3. Description of important insects

The pest insects associated with Juniper forests in Uzbekistan is extremely poorly known. Gershun et al. (1954) and FAO (2007) present a very general approach which is far from complete. Further investigation of wood boring insects and pests in this region is in dire need.

6.3.1. JUNIPER WOOD BORER (*ANTHAXIA CONRADTI*)

Colour: Dark bronze to almost black, slightly glossy.
Appearance: Length 4-7mm; body covered with sparse grey hairs (setae)
Flight period: 2nd half of April – middle June, occasionally later
Damage: Larvae developed from eggs laid on the bark surface gnaw into the cambium where they feed on the phloem (sapwood). They overwinter as larva and develop into adults the following summer. It is not known whether they are capable of killing trees.

6.3.2. JUNIPER CAPRICORN BEETLE (*SEMANOTUS SEMENOVI*)

Colour: Brown with brown-yellow spots on the wings.
Appearance: 10-16mm
Flight period: End of March – June
Damage: This species has been recorded to be able to kill trees which have already been weakened. Eggs are deposited in bark cracks and the first larvae emerge in May. They dig into the sapwood where they feed on the phloem and at later larval stage they excavate galleries in the trunk. The larva overwinters within a small cradle inside the trunk and pupates late July the following year. Late August, the new generation of adults emerge and goes almost straight into hibernation.

6.3.3. JUNIPER PHLOEM BEETLE (*PHLOEOSINUS TURKESTANICUS*)

Colour: Black with rusty-red wing covers, pronotum and outer legs.
Appearance: 2.6-2.8mm.
Flight period: Late August and early spring.
Damage: Both larvae and adults overwinter. Overwintering adults lay eggs in late April and continues throughout June. By late July, newly emerged adults mass emerge and feed on young shoots in the canopies, causing loss of shoots and buds as well as thinning and discoloration of foliage. Late autumn, a new batch of eggs is deposited on fresh material and larvae develop before hibernation.

7. SOIL CLASSIFICATION AND DESCRIPTION

Arnold Arnoldussen and Talant N. Sydykbaev

7.1. Methods

The chemical composition of the soil layers is due to the biogeochemical cycling (Fig. 7.1). In the Yan area the following soil data are gathered:

- Soil profile development
- Chemical characteristics per soil horizon
- Soil texture
- Soil moisture content of the top soil.

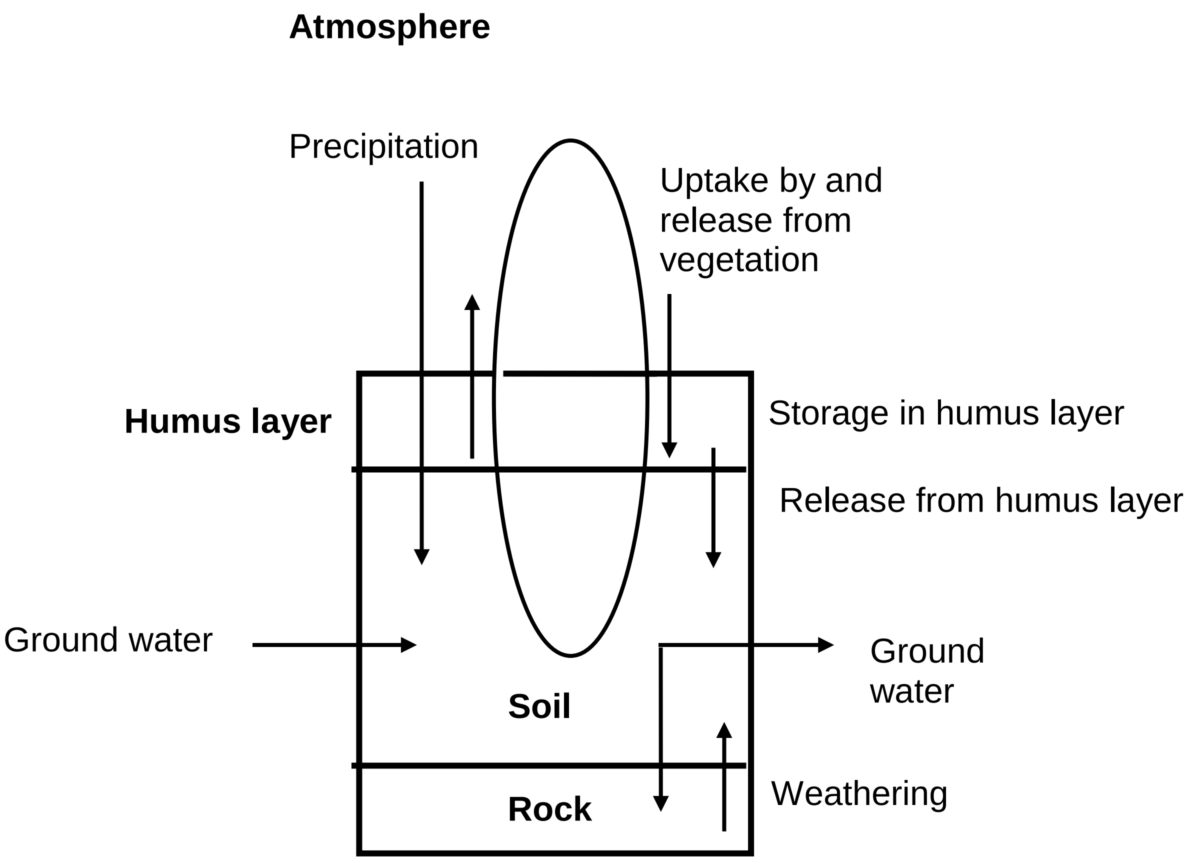


Fig. 7.1. Simplified model of biogeochemical cycling of elements.

The methodology for placing the macro plots and 1m^2 vegetation plots is described in 4.1.1. From the 7th – 8th of May 2009 soil samples were collected from each 1-m^2 plot. The field work was done under sunny circumstances at temperatures around 22 °C. At the 9th of May heavy rainfall started. The period just before sampling was also characterised by periods with heavy rainfall. The soil sampling was done per soil horizon. For each 1m^2 plot the sampling horizon and the depth of sampling was recorded. Samples were taken (see chapter 8 for more details) from 3 sides outside each of the 1m^2 plots. Soil samples were not collected at the slope above the 1m^2 plots in order to avoid disturbances. Sampling was done with the help of an Edelman auger and the maximum reachable sampling depth was 1.20 m. In cases where the presence of free chalk was expected this was controlled with the aid of a solution of 1M HCl. Per 1m^2 plot one mixed soil sample was collected and put in a 0.5 litre sample box. After field work the boxes were stored at a cool and dry place. Soil moisture samples were taken during the vegetation description in July 2009.

Outside each macro plot a simplified soil profile description was made for the soil which should be considered as characteristic for the macro plot. Data on soil texture of each soil sample were not gathered. Soil texture data from the simplified texture descriptions can be used indicative.

7.2. Results

Yangonkli-Sai as the nearby Umalak Teppa site is ecologically very diverse: (i) slopes facing north and south, (ii) macro-plots grazed (3 – 7) and ungrazed (1 – 2 and 8 – 10), (iii) north slope with loess and south faced slope with weathered gneiss and rhomb porphyry, (iv) loess soils with a calcareous B and C horizons (sometimes also the A horizon) while the weathered soils were degraded and sometimes with heavy clayey with rocky outcrops, and (v) big and well developed *Juniperus* trees on north faced slope, sparse and small on south faced slope.

The soils on the north slope (macroplots 1 – 2 and 4 - 10) were Luvisols. The soil had a well developed B horizon and the C horizon was sometimes not possible to reach. These soils were calcareous and some had secondary chalk noodles. Soil texture varied from a silty loam to a loamy clay.

All the non-fenced parts (macroplots 3 - 7) showed clear signs of overgrazing. Erosion features were common. The downward stream is used twice a day by sheep herds going to or coming from the grazing grounds and they pass through a relatively small corridor. In the fenced part of the macroplot 1 – 2 it is clearly seen that shrubby vegetation is getting established. A part of this fenced area is an old apricot orchard.

One macroplot (3) is established on the weathered rhombyrporfyr. Here a Leptosol is present. The vegetation is dominated by *Eremurus*. The soil does not react with HCl.

The soils on the south slope were totally different (macroplot 3). Generally the slope is steep and consists of weathered gneiss/rhombyrporfyr rocky outcrops. The weathered material is varying in texture from sandy silt to a loam to very heavy clay. The soil was not calcareous.

The south slope is severely overgrazed and the large parts of the vegetation are dominated by *Eremurus*. Due to overgrazing the soil profile is a B or BC profile. Soiltypes found are Regosol and Leptosol. Around macroplot 5 several small springs were coming out of the slope.

7.3. Discussion

The big ecological diversity makes Yan a very interesting site. Over time the influence of fencing will become even more visible. The difference in geological deposit has a clear influence on the potentials for forest development.

The soil in Yan is more developed than in the nearby Umalak Teppa site. The reason for this is not known. It could be the age of the site and/or the difference in climate/micro climate (precipitation).

8. SOIL CHEMISTRY

Rolf D. Vogt

8.1. Methods

8.1.1. SAMPLING DESIGN

Soil samples were collected close to each of the $1m^2$ plots in order to produce soil data that are representative for the ground vegetation analysis. For details in sampling design, see chapter 7.1. The sampling design, restricted random sampling, also permits the use of statistics on the soil data.

Sampling spots were selected not to disturb leakage of water. The soil samples are therefore collected at a distance of 20-30 cm from the left, right and down-slope side of each $1m^2$ plot, i.e. not above any of the $1m^2$ plots. Apart from that, the spots were distributed evenly around the $1m^2$ plots, to make a representative sample. Soil was collected by genetic horizon, based on location and appearance. The soil from each soil horizon of the three spots at each $1m^2$ plot, were bulked into one composite sample of the soil horizon. It was attempted to collect equal amounts of soil from each spot, especially when the horizons were thick, i.e. in the B and C horizons. Two or more generic mineral soil horizons (usually A and B horizons) are sampled. The O horizon (mixing of the fermentation (F) and humic (H) horizons) were not sampled at all sites since the O horizon was lacking in several of the $1m^2$ plots. The actual classification of the horizons at which the soil was collected can only be done after sampling and analysis. An examination in retrospect confirmed that the soil horizons were correctly classified. The horizon notations mentioned are therefore used.

The soil from the A horizon was sampled by hand using a small plastic spade. For the collection of B horizon samples, an Edelmann auger was generally applied. There are several uncertainties connected with the soil sampling:

- It was sometimes difficult to separate the horizons due to similarities in colour or diffuse boundaries.
- Some places the A horizon was quite thin, which gives a high risk of contamination of the A horizon sample by soil from the O or B horizons.
- The use of the auger could produce mixing of horizons when they were thin.
- The bulking of the samples produce a risk of mixing of soil from different horizons due to spatial variation in soil profiles. This problem was attempted minimized by only bulking soil of equal colour.

Minimum and maximum soil horizon depths were noted, but the measurements were approximate as it was difficult to see down in the augered hole to determine where the borders between the different horizons were.

8.1.2. SOIL CHEMISTRY PARAMETERS

The samples were analysed in duplicates (i.e. two parallels). In case of small sample size the parallels were dropped and the parameters were prioritised in the listed order as given in Tab. 8.1.

Tab. 8.1. Description of chemical methods to be used for the soil analysis.

Parameters	Methods and comments	Reference
1. Dry matter	1. Gravimetric loss after drying at 105 °C	1. ISO11465
2. pH_{H2O}	2. pH in extracts of the soil	2. ISO10390
3. Total C	3. Manually or by HCN analyzer	3. ISO10694
4. Total N	4. Kjeldahl N	4. ISO11261
5. Effective exchangeable Ca,Mg,Na & K and CEC	5. $BaCl_2$ at pH 8.1 extraction and the extractant analysed for Ca, Mg; Na, and K, by ICP-AES.	5. ISO13536
6. Loss on ignition (LOI)	6. Gravimetric loss after combustion	6. Krogstad, 1992
7. Adsorbed PO_4	7. Extraction with H_2SO_4 and HCl or HCO_3^-; determination by CM	7. Olsen & Sommers (1982), Olsen (1953)
8. Major and minor metals	8. ICP-AES metal scan on samples digested with Aqua regia	8. Standard method
9. Water & Acid soluble SO_4	9. HCl and water extracted SO_4 and the amount determined gravimetrically	9. ISO11048

8.1.3. SOIL CHEMISTRY ANALYSES

Soil samples from Yangonkli-Sai were analyzed at Central laboratory of the State Committee of Geology of the Republic of Uzbekistan, Tashkent and in The Research institute of soil science.

8.1.3.1. Dry matter

The dry matter content (w_{dm}) or water content on a dry mass basis (w_{H2O}) is determined as described in ISO11465 using air-dried (20 ºC) soil passed through a 2.00 mm aperture sieve. Soil samples are dried using a Gallencamp Drying oven to constant mass at 105 ± 5º C for 12 hr. The difference in mass of an amount of soil before and after the drying procedure is used to calculate the dry matter and water contents on a mass basis. The factor w_{dm} and w_{H2O} are used in all the following methods (except: 2. Soil pH) to correct for humidity in the air-dried sample.

8.1.3.2. Soil pH

A suspension of the air-dried soil passed through a 2.00 mm aperture sieve is made up in five times its volume of water. The pH of the suspension is measured using a pH meter (Mettler Toledo Seven Easy) as described in ISO10390.

8.1.3.3. Total carbon (C)

Total C includes both inorganic and organic C. Inorganic C is principally found in carbonate minerals, whereas most organic C is present in the soil organic matter fraction.

The measurement of total C is conducted according to ISO10694 on air-dried soil passed through a 2.00 mm aperture sieve. This is conducted by a dry combustion technique on a LECO carbon analyzer (SC-225). The soil sample is oxidized to CO_2 at 940 ºC on CuO in a flow of oxygen-containing gas that is free from carbon dioxide; the released gases are scrubbed; and the CO_2 in the combustion gases is measured using an infrared (IR) detector.

Organic C is measured on 10% of the samples, making sure to include a broad span of LOI (see chapter. 8.1.3.6) in the selected samples. The measurement of organic C is also conducted according to ISO10694. For the determination of organic carbon content, any carbonates present are previously removed by treating the soil with hydrochloric acid.

8.1.3.4. Total nitrogen (N)

Total N is determined as nitrogen of organic matters in the form of ammonia after digestion of organic matters by heating with sulphuric acid and using mercury sulphate as catalyst. Ammonium was determined using a Spectrophotometer Camspec.

8.1.3.5. Effective CEC

The potential CEC is determined as described in ISO 13536, determining also the sodium, potassium, calcium and magnesium in the barium chloride extracts of the soil.

Extracted Ca, Mg, Na and K were determined using an Atomic emission spectrometer with inductively coupled plasma ICP-AES Optima 5300DV.

8.1.3.6. Loss on ignition (LOI)

The organic content is measured as Loss on Ignition (LOI) according to Krogstad (1992) by measuring weight loss before and after burning of the organic matter in a furnace at 550 ± 25 °C.

8.1.3.7. Available phosphate (P)

The phosphate in acid and neutral soils (i.e. soil samples from 1-m^2 plots with an A-horizon having a $pH_{H2O} < 7.5$) is extracted using Mehlich's method and in alkaline soils (i.e. soil samples from 1-m^2 plots with an A-horizon having a $pH_{H2O} > 7.5$) using Olsen-P method.

The Mehlich’s method uses a mixture of sulphuric and hydrochloric acid to de-sorb the phosphate according to the method described by Olsen & Sommers, 1982. This method is effective in extracting Ca-P, Fe-P and Al-P in acid and neutral soils.

In the high pH soils (>7.5) the acid extractants become less effective. These soils contain free calcium carbonate which neutralizes the acid and prevents the extraction of P into solution. Instead, the Olsen's extractant (Olsen 1953) uses a buffered 0.5 M sodium bicarbonate solution ($NaHCO_3$ at pH 8.5) which is alkaline and designed for use on calcareous soils. This extractant suppresses Ca^{2+} by both the high HCO_3^- concentration and high pH, allowing phosphates to dissolve out of calcium phosphate minerals (by the common ion principle). This extractant is therefore excellent at extracting calcium-P, the dominant form of P in calcareous soils.

8.1.3.8. Major and minor metals

The soil sample is dissolved in aqua regia and the solution is determined for Ca, Mg, Na, K, Al, Fe, Mn, P, Ba, Pb, Cd, Cu, Cr, As, Zn, Ni, Co, V, La, Be, Mo, Sc, Sr, Ti, Y, Zr, Hg, Ag, Bi, Sb, Se, Sn, Te, W, Rb, Nb, Cs, Ce, Th, U and Tl on the Atomic emission spectrometer with inductively coupled plasma ICP-AES according to the standard method used at the Central laboratory.

8.1.3.9. Extractable sulphate

The water-soluble and acid-soluble sulphate is determined as described in ISO11048. The samples are extracted with dilute hydrochloric acid and water and the sulphate content in the extracts is determined by gravimetric method in which barium chloride is added to the extracts and the precipitate of barium sulphate is dried and weighted.

8.2. Results

8.2.1. SOIL CHEMISTRY DATA

Average soil chemical data for each horizon are presented in Table 8.2. A pH around 7.5 prevails at all the sampling plots and soil horizons. The pH does therefore not decrease from the A to the C horizon as commonly found, though the organic content (measured as Loss on Ignition (LOI) decreases from the A to the B and C horizons along with total Carbon content ($\%C_{tot}$). Studying all samples (across horizons) we find that strong correlations (i.e. $r > 0.7$) between soil chemical characteristics were only found between $\%C_{tot}$ and LOI ($r = 0.777$) and Total N ($r = 0.724$) content. The soil content of adsorbed phosphate (Ads. PO_4^{3-}) is among the lowest amongst all sites studied, including TEMP-CA sites.

Tab. 8.2**.** Average and quartiles of soil chemical characteristics for Yangonkli-Sai. LOI denote Loss on Ignition**.**

Horizon	Number of samples	pH_{H2O}	LOI	C total	Total N	Ads. PO_4^{3-}
			w/w%		µg/g	
A	40	7.51	11	6,5	3366	20
		7.5-7.5	8-12	5-7	2740-4120	9-15
B	50	7.52	5,7	1,9	1474	11
		7.6-7.5	4-7	1-2	1105-1800	6-9
C	20	7.50	6,1	1,4	1394	7,6
		7.5-7.5	5-7	1-2	753-1290	5-8

In addition to SiO_2 (not measured) the main (avg. value > 3,5 mg/g) oxide composition of the mineral soils (Figure 8.1) is made up by aluminium (Al) and iron (Fe), followed by calcium (Ca) and potassium (K). Base cations (Ca+Mg+Na+K) in the A and B horizons account for about 40% - 50% of the oxide composition. The C horizon is richer in base cations, likely due to that the weathering has not been as active as in the A and B horizons.

The content of Fe and Al are strongly correlated ($r = 0.886$). Both Al and Fe are correlated to manganese (Mn) ($r = 0.850$ and 0.951, respectively). The Al content is also as commonly found to co-vary with K ($r = 0.848$), in addition to sodium (Na) ($r = 0.818$) as there is a strong correlation between Na and K ($r = 0.903$). The Al and Fe content are also strongly correlated to a number of trace elements such as cupper (Cu) ($r = 0.803$ & 0.756), nickel (Ni) ($r= 0.809$ & 0.817), cobalt (Co) ($r = 0.884$ & 0.974), scandium (Sc) ($r=0.914$ & 0.942), caesium (Cs) ($r =0.815$ & 0.916) and as usual with titanium (Ti) ($r = 0.943$ & $r=0.872$, respectively).

The major oxide elements presented in Figure 8.1 are followed in abundance by Ti, total phosphorous (P), Mn and barium (Ba) (Table

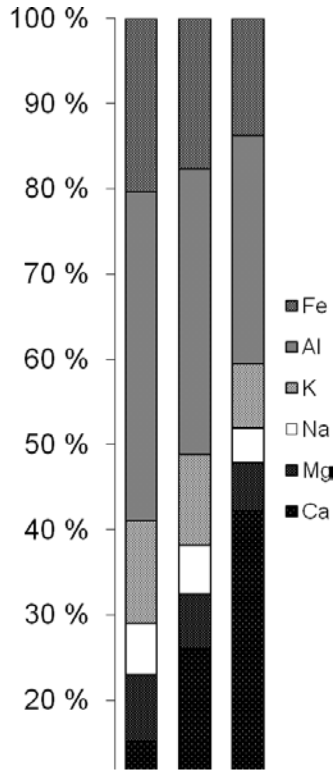


Fig. 8.1. Main (avg. value > 3.5 mg/g) oxide composition of the mineral soils.

3). Ba content in these soils was high, especially in the B horizon. The amount of Ti was also relatively high compared to e.g. Na. In addition to Al and Fe (see above) the Ti is strongly (r>9) correlated with Mg (r = 0.935) and the heavy metal Co (r = 0.910) and Sc (r=0.922). The spatial variation in lanthanum (La) is as commonly found correlated with the trace elements Co, Sc, yttrium (Y), zirconium (Zr) and cerium (Ce). Total P appears to be strongly governed by the Al (r = 0.829) due to strong binding as $AlPO_4$. In addition to Fe and Al (see above) the Mn was strongly correlated to K (r = 0.915) and Co (r = 0.918). The Ba was only found to correlate with Ti, Na, K, Cu and Sc.

Tab. 8.3**.** Soil average and quartile content of less abundant oxide elements in 40 A, 50 B and 20 C horizon samples from Yangonkli-Sai.

Horizon	P	Mn	Ti	Ba	La
	mg/kg				
A	1300	830	3608	601	28
	708 -968	653 - 1000	2775 – 4600	475 - 703	22 – 34
B	786	733	3420	715	26
	600 – 803	540 -905	2600 – 4125	530 – 760	20 – 32
C	899	708	3700	581	26
	610 -1200	638 - 800	3375 – 4300	520 – 635	23 – 27

Soil composition of measured trace elements along with the composition of continental crust (Taylor and McLennan, 1985) and selected heavy metal contamination norms (Lacatusu, 1998) are presented in Table 8.4. The bedrocks in the studied sites are generally secondary minerals (sandstone, clay and limestone) that are apparently partly transformed to shale and marble by metamorphosis. The contents of trace elements are therefore generally depleted compared to continental crust. Generally the heavy metal contents are high relative to normal background levels typically found in soils and the values lies between the normal maximum levels and the various maximum allowable limits (M.A.L.) adopted by different countries (see e.g. Naturvårdsverket (1997) for relevant values for forest soils (Table 8.4).

Tab.8.4. Soil content of measured trace elements in 36 A, 14 B and 35 C horizon samples along with some reference values

Site	Hor	As	Sr	Pb	Cd	Cu	Cr	Zn	Ni	Co	V	Sc	Y	Zr	Be	Mo
		mg/kg														
Earth crust[1]		1.0	260	8.0	0.1	75	185	80	105	29	230	30	20	100	1.5	1.0
Normal Min[2]				0.1	0.1	1	2	3	2	1						
World mean[3]		6	300	10	0.06	20	100	50	40	8						
M.A.L. (PI) [2]				100	3	100	100	300	100	50						
YAN	A	3.1	177	36	0.2	40	66	98	64	15	95	15	20	86	3.9	2.2
	B	3.2	204	22	0.2	30	58	73	56	14	106	13	18	84	2.1	1.5
	C	3.1	244	18	0.1	32	56	73	63	14	94	14	20	86	2.8	1.4

[1] Taylor & McLennan (1985).
[2] Maximum allowable limits. See: http://eusoils.jrc.it/esdb_archive/eusoils_docs/esb_rr/n04_land_information_systems/5_7.doc
[3] World mean concentration in uncontaminated soils (Allaway1968)

As described above the Al and Fe content is strongly correlated to a set of the 33 measured trace elements in the 110 soil samples (for Fe see Figure 8.2) from 3 soil horizons in 50 soil plots in 10 macroplots at the site. Important exceptions are the soft (or type B) metals with poor negative correlations to mercury (Hg), cadmium (Cd), thallium (Ti) and no correlation to silver (Ag), and some of the hard (type A) elements such as strontium (Sr). Soft metals (high covalent index) were instead generally found to be correlated only to each other (Table 8.5) and negatively correlated to hard (Type A) metals (e.g. Ca, Mg, Ba and Sr).

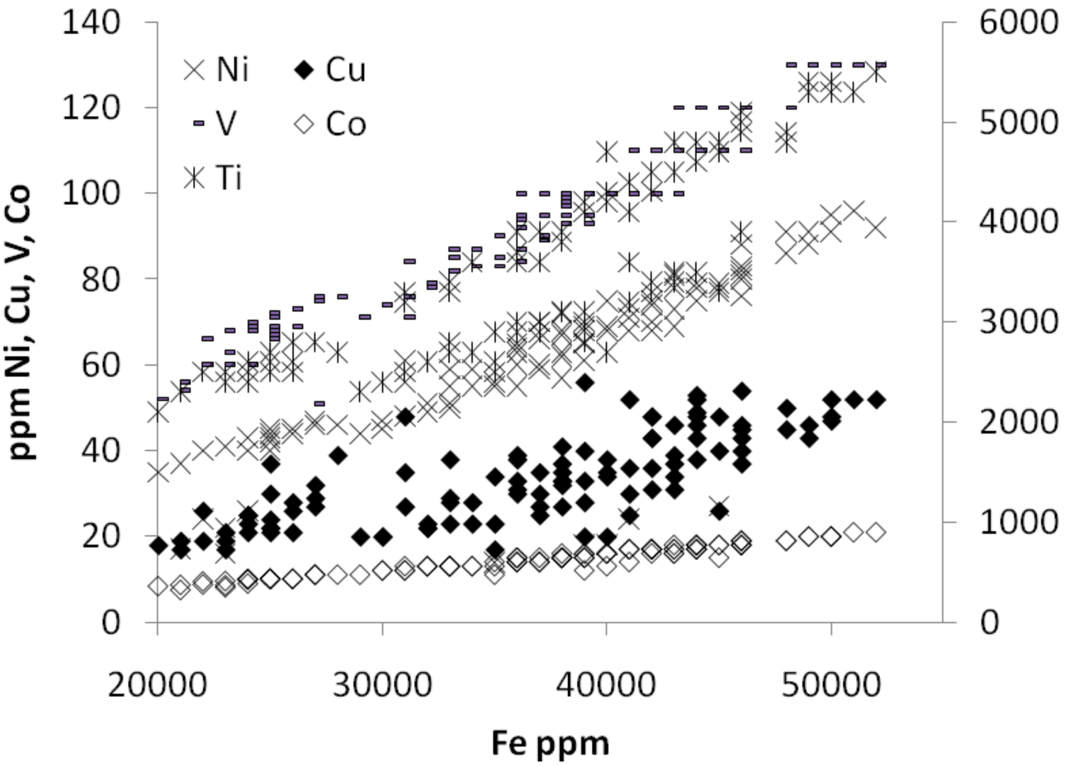


Fig. 8.2**.** Correlation between soil content of iron (Fe) and elements manganese (Mn), titanium (Ti), cobalt (Co), scandium (Sc) and vanadium (V).

The amounts of most trace elements co-varied in the soils across all soil plots and soil horizons; 51 strong correlations were found between the 33 measured trace elements (Table 8.5). As usual the borderline elements cobalt (Co), Ni, scandium (Sc), caesium (Ce) and lanthanum (La) showed the largest number of strong correlations (Table 8.5). The type B elements (Ag, Te, Bi, Hg, Tl, W, Se & Sb) and the type A elements (Be, U, Sr & Rb) were among the poorest correlated to the other trace elements. Scandium and cobalt had the largest number of correlations and showed also the strongest correlations.

Tab. 8.5. The strongest sets of correlations (i.e. r > 0.700) found for each of the measured 33 trace elements in 40 A, 50 B and 20 C horizon samples from YAN. The elements are sorted in the order of their covalent index with type B elements on the top and type A elements in the bottom. - Indicates no strong (r > 0.7) correlations.

	# of corr.	Vs.	r
Pb	2	Mo	0.808
Ag	1	Te	0.886
Te	1	Ag	0.886
Bi	0	-	-
Hg	0	-	-
Tl	0	-	-
W	0	-	-
Se	0	-	-
Sb	0	-	-
Mo	3	Zn	0.829
Cd	0	-	-
As	5	Co	0.781
Sn	0	-	-
Cu	6	Sc	0.847
Co	11	Sc	0.971
Ni	7	Sc	0.930
Zn	4	Mo	0.829
Nb	2	Zr	0.760
Th	6	La	0.767
V	0	-	-
Ti	5	Sc	0.922
Cr	1	Th	0.706
Sc	11	Co	0.971
Y	6	Ce	0.932
Ce	10	Sc	0.954
La	9	Ce	0.892
Zr	6	Y	0.914
Ba	2	Cs	0.770
Cs	2	Rb	0.849
Rb	1	Cs	0.849
Sr	0	-	-
U	1	Ba	0.742
Be	0	-	-

8.3. Discussion

8.3.1. SOIL CHEMISTRY CONDITION

The role of Fe content as a governing factor for the soil chemical content of trace elements can clearly be illustrated by a Principal Component Analysis (PCA) (Minitab®). More or less the same pattern is found in all the studied sites. In the plane of the first two principal components (PCA 1 and PCA 2) in both the A- and B horizons the Fe is clustered together with Al and most trace elements (Figure 8.3). Negatively loaded to this cluster along the PCA 1 axes we find mercury (Hg), cadmium (Cd) and thallium (Tl). The PC1, explaining 42.6% and 38.7% of the variation in the A and B horizon, respectively, is therefore mainly explained by the Al and Fe relative to B element content. The PCA 2 at most of the TEMP-CA sites (e.g. Økland et al 2011) is mainly explained by the Covalent index (CI = X^2r) of the elements, but this does not appear to be the case at YAN. This may partly be due to that this is partly explaining the variation in the PC1, with typically hard trace elements having negative or low loading and soft elements having high positive loading.

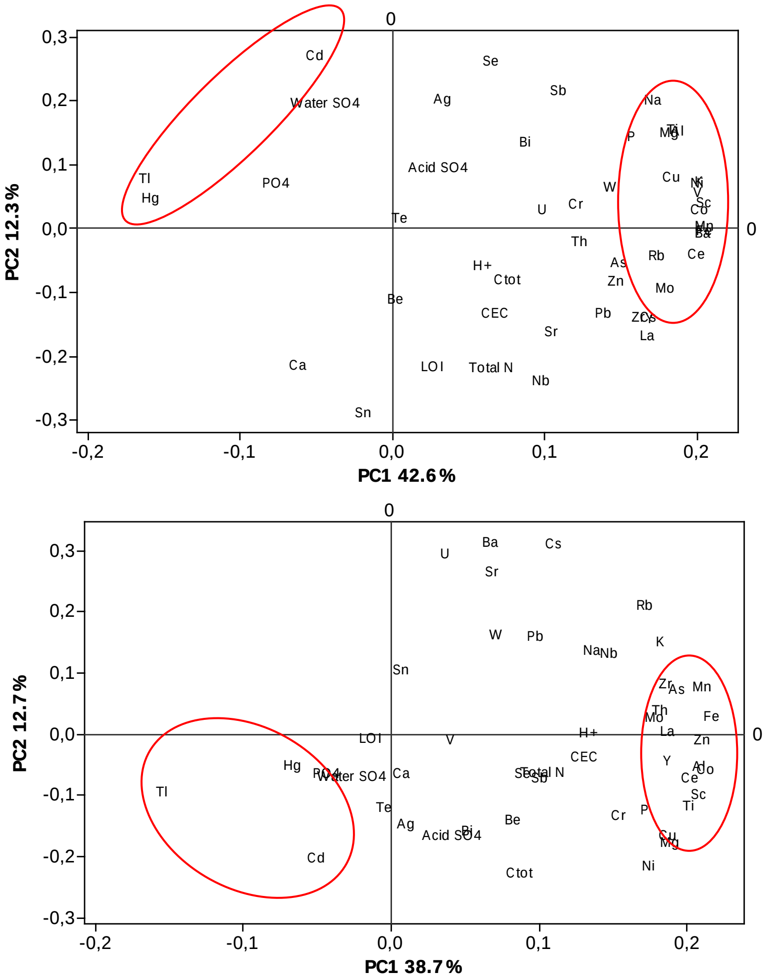


Fig. 8.3. Parameter loading along the two first principal components in a PCA analysis of soil data from the A horizon (top graph) and B horizon (bottom graph), explaining 54.9 and 51.4% of the variation in soil elemental composition, respectively.

9. AIR POLLUTION

Karl H. Thunes and Karine Mirumyan

9.1. Methods

A survey was carried out to identify some of the production facilities present within range of the Yangonkli-Sai site. Various Russian and international internet resources were visited and the information compiled.

9.2. Results and discussion

Despite various attempts, information about the production facilities in the Angren district was difficult to assess and it was even more difficult to find information about which potentially polluting agents were emitted. The results presented here is therefore limited and based upon internet resources. Nonetheless, there is no indication of unusually high concentrations of polluting agents in the soil (chapter 8).

In Tab. 9.1., some of the industries established in the Angren district are presented which can represent sources to air pollution.

Table 9.1. List of some production facilities and plants located in the Angren district.

ID#	Location	Product
1	Angren	Germanium concentrate, Aluminium salts, non-specified metal compounds
2	Angren	Concrete and concrete materials
3	Angren	Home appliances, gas equipment, heaters
4	Angren	Electricity
5	Zhigoriston	Coal
6	Geolog	Mining activity, iron, alloying elements, tungsten, heavy metals, gold, silica, quartz
7	Angren	Raw mineral exploration, contractor for mining industry
8	Angren	Cement, mining rock material, clay and aluminium
9	Angren	Building bricks and ceramic tiles
10	Angren	Electricity
11	Angren	Coal mining and kaolin clay, aluminium
12	Angren	Gold exploration, mining solid minerals, mining services of uranium
13	Angren	Rubber products
14	Angren	Oil, gas and solid minerals exploration
15	Angren	Galvanic cell batteries

We do not know the extent or magnitude of the facilities (production volume), neither do we have access to information about cleaning or recycling facilities and regulations. Consequently, we can not infer any connection between these establishments and the degeneration of Juniper trees in Yan.

9.2.1. AGENTS

Germanium is a byproduct from production of copper, lead and zink. It is toxic in its hybrid form “Germaine”, a colorless gas.

Production of cement is a main source for dust as well as waste products containing mercury and sulphur dioxide

Coal power plants are a major source for acidification of the environment as well as emission of greenhouse gases.

The mining operations that are done in order to purify gold can cause atmospheric discharges of heavy metals, suspended particulates as well as sulphates, and cyanides.

Uranium itself is not very toxic to the environment. However, the ores may contain high levels of radium and other radioactive substances.

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